CONNECTICUT RIVER BASIN

MANCHESTER, CONNECTICUT

HOWARD RESERVOIR DAM

CT 00015

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
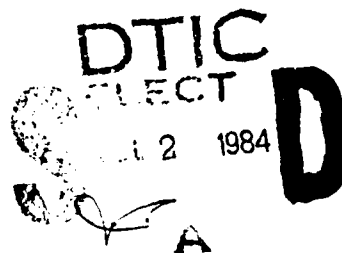
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JUNE 1979 84 06 2° 06

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
DAMS, INSPECTION, DAM SAFETY,

Howard Reservoir Dam, Conn. River Basin, Manchester Conn.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Howard Reservoir Dam is an earth embankment about 710 ft. long, with a maximum height of about 50 ft. and a crest width of about 15 ft. The spillway is located at the right abutment of the dam. It consists of a paved channel; a 10 ft. wide ogee crested weir; and training walls extending 3 ft. above the spillway crest to elevation 492 MSL, at 2½ horizontal to 1 vertical. The gate tower, a wet well shaft, is located on the crest of the dam at its mid-span. It has 14 in. dia. and 20 in. dia. blowoff pipe and a 14 in. dia. gravity flow pipe leading to Porter Reservoir provide the outlets from Howard Reservoir. It is utilized as a water storage facility by the City of Manchester.

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REPLY TO
ATTENTION OF:

NEDED

OCT 5 1979

Honorable Ella T. Grasso
Governor of the State of Connecticut
State Capitol
Hartford, Connecticut 06115

Dear Governor Grasso:

Inclosed is a copy of the Howard Reservoir Dam Phase I Inspection
Report, which was prepared under the National Program for Inspection of
Non-Federal Dams. This report is presented for your use and is based
upon a visual inspection, a review of the past performance and a brief
hydrological study of the dam. A brief assessment is included at the
beginning of the report. I have approved the report and support the
findings and recommendations described in Section 7 and ask that you
keep me informed of the actions taken to implement them. This follow-up
action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environ-
mental Protection, the cooperating agency for the State of Connecticut.
In addition, a copy of the report has also been furnished the owner,
the city of Manchester.

Copies of this report will be made available to the public, upon
request, by this office under the Freedom of Information Act. In the
case of this report the release date will be thirty days from the date
of this letter.

I wish to take this opportunity to thank you and the Department of
Environmental Protection for your cooperation in carrying out this
program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

HOWARD RESERVOIR DAM
CT   00015

CONNECTICUT RIVER BASIN
MANCHESTER, CONNECTICUT

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

A-1

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:   CT 00015
Name of Dam: Howard Reservoir Dam
City: Manchester
County and State: Hartford County, Connecticut
Stream: Porter Brook
Date of Inspection: 9 April and 10 May 1979

BRIEF ASSESSMENT

Howard Reservoir Dam is an earth embankment about 710 ft. long, with a maximum
height of about 50 ft. and a crest width of about 15 ft. The spillway is located
at the right abutment of the dam. It consists of a paved channel; a 10 ft. wide
ogee crested weir; and training walls extending 3 ft. above the spillway crest
to elevation 492 MSL. Above the top of the walls, the spillway opening becomes
a modified V-notch with unpaved earthen side slopes rising to the top of dam,
elevation 496 MSL, at 2½ horizontal to 1 vertical. The gate tower, a wet well
shaft, is located on the crest of the dam at its mid-span. It has 14 in. dia.
and 20 in. dia. inlet pipes at elevations 469 MSL and 454 MSL, respectively. A
24 in. dia. blowoff pipe and a 14 in. dia. gravity flow pipe leading to Porter
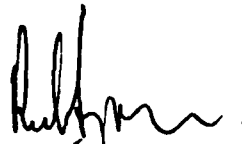Reservoir provide the outlets from Howard Reservoir.

Howard Reservoir is utilized as a water storage facility by the City of Man-
chester. It is about 1,500 ft. long and has a surface area of 18 acres at spill-
way crest level. The drainage area is about 0.86 sq. mi. (550 acres) and the
maximum storage to top of dam is 478 acre-ft. In accordance with size and capa-
city criteria, the dam is classified as intermediate in size. Because a breach
of the dam would affect about 15 homes, a school and a local road, with the
possibility of more than a few lives being lost and the probability of appre-
ciable economic losses, it has been classified as having a high hazard potential.

Brush growth is becoming well established on the downstream slope. Minor
seepage is evident at the downstream toe of the embankment about 300 ft. from
the left abutment. There is a large rodent hole about 4 in. dia. and 3 ft.
deep at the toe of the slope approximately 50 ft. to the left of the gatehouse.
The dam is judged to be in generally good condition.

The PMF test flood inflow of 2,600 cfs could overtop the dam by 0.7 ft., the
total outflow being about 2,300 cfs. The spillway is adequate to pass an out-
flow corresponding to about 42 percent of the test flood outflow. The spillway
discharge at top of dam, elevation 496.0 MSL, is 967 cfs.

Within two years after receipt of this Phase I Inspection Report, the owner, the City of Manchester, should retain the services of a registered professional engineer to make further hydrologic and structural investigations, and should implement the results. These studies should cover: (1) an in-depth assessment concerning the spillway adequacy, the potential for overtopping and possible failure, ways of increasing the total discharge capacity of the dam, and the use of stoplogs; (2) whether the spillway training walls should be raised to the top of the dam; and (3) whether downstream spillway channel modifications are required to forestall possible overtopping of the walls.

The owner should also implement the following measures: (1) remove and control brush growth on the downstream slope; (2) remove tree growth from the spillway channel; (3) backfill the rodent burrow near the toe of the downstream slope and monitor the embankment for new burrows; (4) repair all spalled and deteriorated concrete; (5) stoplogs on the spillway crest should not be used until all the above recommendations and all other remedial measures have been implemented; (6) monitor seepage at the toe of the dam during periods of high reservoir level and at least once a year; (7) develop a formal surveillance and flood warning plan; and (8) institute procedures for a biennial periodic technical inspection of the dam and appurtenant works.

Peter B. Dyson
Project Manager
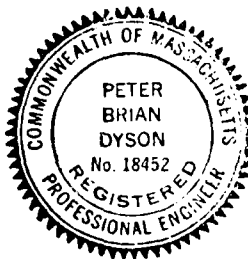
PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation: however, the investigation is intended to identify any need for such studies.
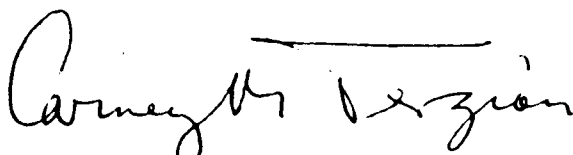
In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.
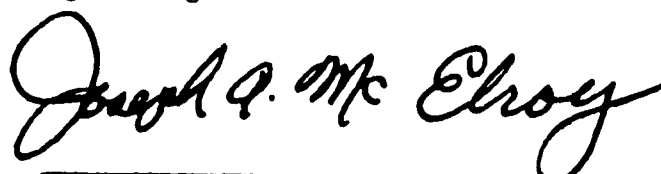
It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

This Phase I Inspection Report on Howard Reservoir Dam
has been reviewed by the undersigned Review Board members. In our
opinion, the reported findings, conclusions, and recommendations are
consistent with the Recommended Guidelines for Safety Inspection of
Dams, and with good engineering judgment and practice, and is hereby
submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
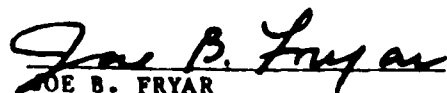Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

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APPENDIXES

HOWARD RESERVOIR DAM

Overview of dam from left abutment

Overview of dam from right abutment

HOWARD RESERVOIR DAM

LOUIS BERGER & ASSOC.,INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HOWARD RESERVOIR DAM

ROCKVILLE QUADRANGLE

CONNECTICUT RIVER BASIN   **STATE - CT.**

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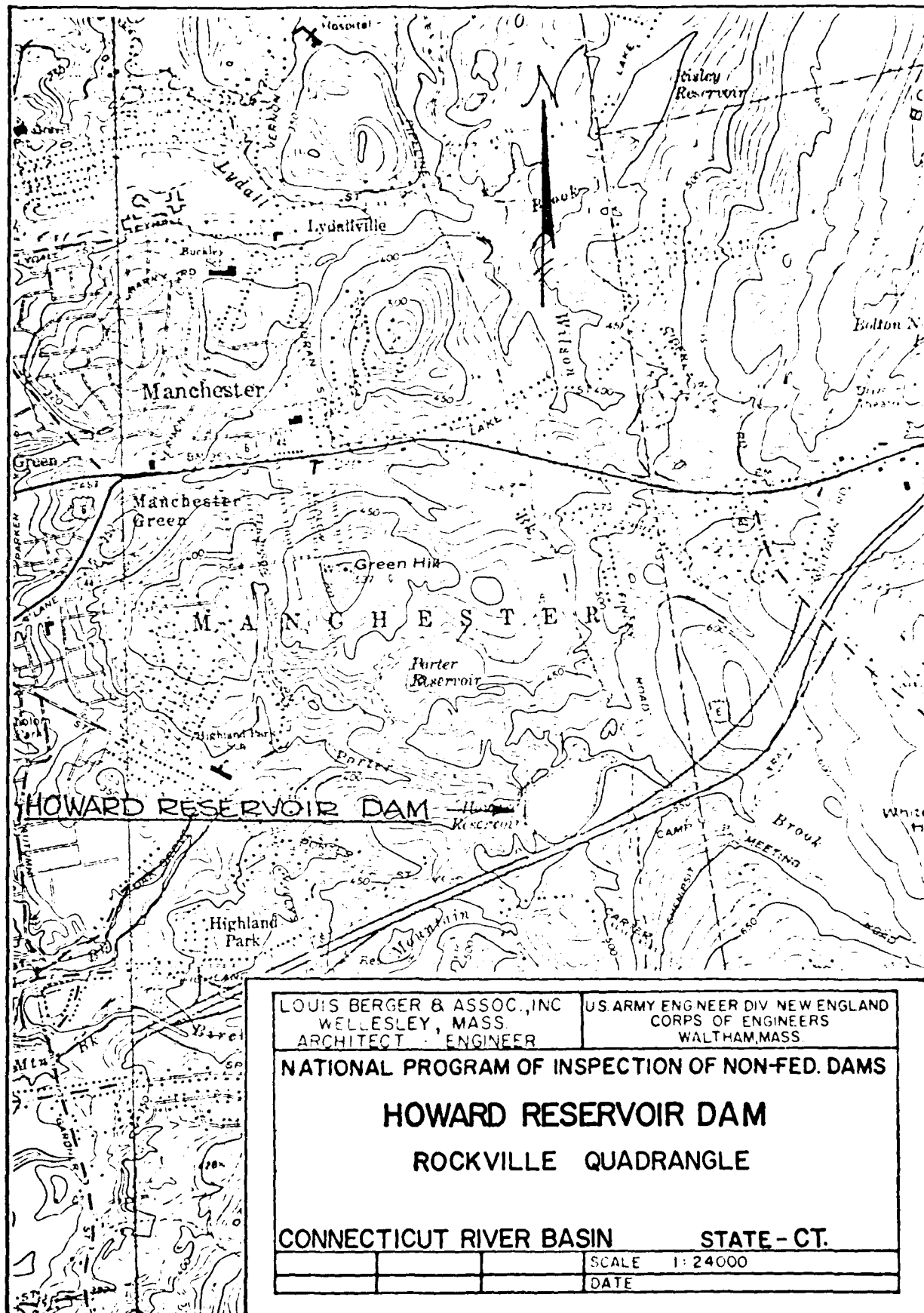
PHASE I INSPECTION REPORT

HOWARD RESERVOIR DAM   CT   00015

Section 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the
Secretary of the Army, through the Corps of Engineers, to initiate a nation-
al program of dam inspection throughout the United States. The New England
Division of the Corps of Engineers has been assigned the responsibility of
supervising the inspection of dams within the New England Region. Louis
Berger & Associates, Inc. has been retained by the New England Division to
inspect and report on selected dams in the State of Connecticut. Authoriza-
tion and notice to proceed was issued to Louis Berger & Associates, Inc.
under a letter of 19 March 1979 from John P. Chandler, Colonel, Corps of
Engineers. Contract No. DACW33-79-C-0051 has been assigned by the Corps of
Engineers for this work.

b. Purpose.

(1) Perform technical inspection and evaluation of non-Federal dams to
identify conditions which threaten the public safety and thus permit correc-
tion in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam
safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Howard Reservoir is located in the City of Manchester,
Hartford County, Connecticut about 1 mile southeast of the I-84 and Route 85
interchange. The dam is situated at the headwaters of Porter Brook which
flows from Howard Reservoir about 2 miles to its confluence with Hop Brook,
a tributary of the Connecticut River. It is shown on U.S.G.S. Quadrangle,
Rockville, Connecticut with coordinates approximately at N41° 46' 15",
W72° 28' 43". The normal storage level of the reservoir at spillway crest
is 489 MSL.

b. Description of Dam and Appurtenances.

(1) Description of Dam. Howard Reservoir Dam is an earthfill embank-
ment about 50 ft. high and 710 ft. long. The dam was constructed of gravel
and impervious fill material. It has a central core wall, apparently of
masonry construction, that extends from a core trench to within 4 ft. of
the top of the dam and for the full length of the dam. Sheet piling extends
from the original ground surface approximately 30 ft. deep for the full length
of the dam and about 30 ft. into each of the abutments.

The dam has a crest width of about 15 ft. The upstream slope is about 2 horizontal to 1 vertical and the downstream slope is about 2½ horizontal to 1 vertical. The upstream slope is protected by handplaced riprap to within 2 ft. of its crest. The downstream slope has grass cover with brush intrusion.

The original plans indicate a toe drainage system, consisting of an upper collector and a lower collector, both located near the downstream toe of the embankment at the maximum section. These collectors consist of 6 in. dia. vitrified pipes with open joints, connected to a 12 in. dia. pipe which enters into a weir chamber at the toe of dam and outlets to the downstream channel beyond.

(2) Spillway. The spillway for Howard Reservoir is located at the right abutment of the dam. It consists of a 10 ft. wide ogee crested weir with training walls extending 3 ft. above the spillway crest to elevation 492 MSL. There the spillway opening becomes a modified V-notch, with unprotected earthen side slopes, which rises to the top of dam, elevation 496 MSL, at 2½ horizontal to 1 vertical. There are masonry training walls immediately upstream and downstream of the ogee weir. Beyond the downstream masonry training walls, the 10 ft. wide channel is bounded by about 2 ft. high masonry walls as it continues down the abutment slope to end some 400 ft. below the dam at stream level.

(3) Outlets. The reservoir outlet is from a wet well and gate tower located on the crest of the dam at about its mid-length. A 20 in. dia. low level inlet pipe and a 14 in. dia. high level inlet pipe empty into the wet well shaft, each controlled by gates operated from the top of the shaft. A 24 in. dia. blowoff pipe leads from the bottom of the shaft to the downstream channel. A 14 in. dia. gravity outlet pipe connects Howard Reservoir either to Porter Reservoir or to the City of Manchester water supply lines. Both outlet pipes are controlled by gates operated from the top of the shaft (Appendix B, Drawing No. 4).

c. Size Classification. The Howard Reservoir Dam is about 50 ft. high, impounding a storage of 367 acre-ft. to spillway crest level and 478 acre-ft. to top of dam. In accordance with size and capacity criteria promulgated in the Recommended Guidelines for Safety Inspection of Dams, the project is categorized in the intermediate classification.

d. Hazard Classification. A breach failure of the dam at Howard Reservoir would release water down Porter Brook and thence into Hop Brook. The valley section below the dam would be inundated up to about 20 ft. by a breach flow from the reservoir. It appears that there would be danger of about 15 homes being affected with a possibility of loss of life and appreciable economic loss. The Highland Park School as well as the Porter Street crossing over Porter Brook would also be affected. Consequently, Howard Reservoir Dam has been classified as having a high hazard potential in accordance with the Recommended Guidelines for the Safety Inspection of Dams.

e. Ownership. The Howard Reservoir Dam is owned by the City of Manchester.

f. Operator. Mr. Frank T. Jodiatis, P.E., Administrator, Water and Sewer Department, City of Manchester, 105 N. Main Street, Manchester, CT. Telephone: (203) 647-3113

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g. Purpose of Dam. The Howard Reservoir is operated in conjunction with Porter Reservoir, Globe Hollow Reservoir, and other water storage facilities to supply municipal water to the City of Manchester.

h. Design and Construction History. The construction plans for Howard Reservoir Dam, originally known as Porter Brook Reservoir, were prepared in 1902 by Freeman C. Coffin, Designing Engineer and Desmond Fitzgerald, Consulting Engineer, both of Boston, MA. It is not known for certain by whom the dam was constructed. However, discussions with local officials indicate that the original owners of the dam, Cheney Brothers of South Manchester, may well have constructed the dam.

i. Normal Operating Procedure. There are no written operating procedures. Water is released from the reservoir through the 14 in. dia. pipe either to Porter Reservoir for storage purposes or directly into the City of Manchester's water treatment facilities and thence into the water distribution system. The outlet gate is normally maintained at a fully open position and operation is not a day-to-day procedure.

1.3 Pertinent Data

a. Drainage Area. The drainage area contributing to Howard Reservoir is situated at the headwater of Porter Brook. The drainage area encompasses a total of 0.86 sq. mi. (550 acres), of which 18 acres are occupied by the reservoir. The longest circuitous stream course contributing to the lake is about 8,300 ft. long, with an elevation difference of about 266 ft. or at a slope of about 144 ft. per mile. The drainage area has a length of about 1.2 miles and a maximum width of about 1.1 miles, with an average width of about 0.4 miles. The basin consists of mainly forested areas, and is sparsely populated.

b. Discharge at Damsite.

(1) Outlet Works Conduit. Discharges from Howard Reservoir are provided by a 24 in. dia. blowoff pipe to the stream below and a 14 in. dia. pipe to either Porter Reservoir or the City's distribution system. Both pipes lead from the bottom of a wet well shaft where the control gates for both the outlet and inlet pipes are located. The invert elevation of the outlet pipes is 453.5 MSL.

(2) Maximum Known Flood at Damsite. No records are available of flood inflows into Howard Reservoir, nor of spillway releases and surcharge heads during such inflows.

(3) Ungated Spillway Capacity at Top of Dam. The spillway at the reservoir is an ungated ogee weir. The total spillway capacity at top of dam, elevation 496.0 MSL is 967 cfs.

(4) Ungated Spillway Capacity at Test Flood Elevation. The ungated spillway capacity is about 1180 cfs at test flood elevation 496.7 MSL.

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(5) Gated Spillway Capacity at Normal Pool Elevation. Not applicable.

(6) Gated Spillway Capacity at Test Flood Elevation. Not applicable.

(7) Total Spillway Capacity at Test Flood Elevation. The total spillway capacity at the test flood elevation is the same as (4) above, 1,180 cfs at elevation 496.7 MSL.

(8) Total Project Discharge at Test Flood Elevation. The spillway is inadequate to handle the test flood and the dam would be overtopped by about 0.7 ft. at elevation 496.7 MSL. The total discharge through the spillway and over the dam would be about 2,300 cfs.

c. Elevations (Ft. above MSL)

(1) Streambed at centerline of dam - 444 (+)

(2) Maximum tailwater - Not computed

(3) Upstream invert of outlet pipe - 453.5

(4) Recreation Pool - Not applicable

(5) Full flood control pool - Not applicable

(6) Ungated spillway crest - 489.0

(7) Design surcharge (original design) - Unknown

(8) Top of dam - 496.0

(9) Test flood design surcharge - 496.7

d. Reservoir

(1) Length of maximum pool - 1,400 ft.

(2) Length of recreation pool - Not applicable

(3) Length of flood control pool - Not applicable

e. Storage (acre-ft.)

(1) Recreation pool - Not applicable

(2) Flood control pool - Not applicable

(3) Spillway crest pool El. 489.0 - 329

(4) Top of dam El. 496.0 - 478

(5) Test flood pool El. 496.7 - 501

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f. Reservoir Surface (acres)

(1) Recreation pool - Not applicable

(2) Flood control pool - Not applicable

(3) Spillway crest El. 489.0 - 17.9

(4) Top of dam El. 496.0 - 24.5

(5) Test flood pool El. 496.7 - 26.2

g. Dam

(1) Type - Zoned earthfill embankment

(2) Length - 710 ft.

(3) Height - 50 ft.

(4) Top width - 15 ft.

(5) Side slopes - Upstream 2 horizontal to 1 vertical
                  Downstream 2½ horizontal to 1 vertical

(6) Zoning - Upstream - impervious material, overlain by gravel, then
                         broken stone and then riprap.
             Downstream - pervious material overlain with sod.

(7) Impervious core - Masonry core wall

(8) Cutoff - Below and adjacent to the core wall, a 6 in. wood sheet
             pile wall driven to varying depths; in central portion of
             dam carried to bedrock, at left and right abutments not
             carried to bedrock.

(9) Grout curtain - Unknown

(10) Other - Not applicable

h. Diversion and Regulating Tunnel - None

i. Spillway

(1) Type - Ungated ogee weir

(2) Length of weir - 10 ft.

(3) Crest elevation - 489.0 MSL

(4) Gates - None

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(5) Upstream channel - Masonry training walls with stone pavers.

(6) Downstream channel - Masonry training walls immediately downstream, then about 2 ft. high masonry training walls along spillway channel - entire channel bottom lined with stone pavers.

(7) General - Not applicable

j. Regulating Outlets

(1) Invert - 453.5 MSL

(2) Size - 14 in. and 24 in. dia. pipes

(3) Description - 14 in. dia. pipe leads either to Porter Reservoir or to City distribution system, control regulated downstream by a "T" stem and valve; 24 in. dia. pipe is a blowoff line leading to Porter Brook below dam. The 24 in. dia. blowoff pipe is capable of discharging about 90 cfs.

(4) Control Mechanism - Gate valves in line in wet well at gatehouse, with control hoists.

(5) Other - Not applicable

SECTION 2 - ENGINEERING DATA

2.1 Design Data

The Howard Reservoir Dam and appurtenances were designed by Freeman C.
Coffin, Designing Engineer and Desmond Fitzgerald, Consulting Engineer,
both of Boston, MA. The construction plans were prepared in 1902 and are on
file at the City of Manchester, Water and Sewer Department offices. The
drawings show complete details of the designs and layout (Appendix B), and
indicate that the project was originally known as Porter Brook Reservoir.

2.2 Construction Data

The only records or correspondence found regarding construction is a letter
from the City of Manchester to the State of Connecticut DEP, dated June 2,
1972, stating that the spillway was not constructed as shown on the original
drawings. An ogee crested weir was constructed at the spillway rather than
the proposed broad crested weir with a stepped downstream face.

2.3 Operation Data

The dam is operated by the City of Manchester, Water and Sewer Department.
There appear to be no formal records other than reservoir levels.

2.4 Evaluation of Data

a. Availability. Since no engineering data is available, it is not
possible to make an assessment of the safety of the dam. The basis of the
information presented in this report is principally the visual observations
of the inspection team.

b. Adequacy. The lack of in-depth engineering data did not allow for
a definitive review. Therefore, the adequacy of this dam could not be as-
sessed from the standpoint of reviewing design and construction data, but is
based primarily on visual inspection, past performance history and sound en-
gineering judgment.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General. The visual inspection of Howard Reservoir Dam took place on 9 April and 10 May 1979. The reservoir was at about elevation 489.1 MSL. There was leakage around the toe drain pipe of about 5 gpm. The dam appears to be in a generally good condition.

b. Dam. Howard Reservoir Dam is an earthfill embankment about 50 ft. high, 710 ft. long and has a crest width of about 15 ft. The horizontal and vertical alignment of the embankment is good. The upstream slope is about 2 horizontal to 1 vertical and the downstream slope is about 2½ to 1.

The upstream slope is hand-placed rock riprap and extends to within 2 ft. of the dam crest. The riprap is in generally good condition with no evidence of sags or bulges. However, there is some minor brush growth coming through the riprap (see Photo No. 1, Appendix C).

The downstream slope is grass covered and brush growth is becoming well established. There is a generally wet area located along the toe of the downstream slope for a distance of approximately 50 ft. to the left of the gatehouse; total seepage being about 1 to 2 gpm with the water clear and not carrying any sediment. A rodent hole approximately 4 in. in diameter and 3 ft. deep was noted near the toe of the slope approximately 50 ft. to the right of the gatehouse. The downstream slope is in generally good condition with no evidences of bulges or slope movement (see Photo Nos. 2 and 3, Appendix C).

Seepage through the embankment is collected in the toe drainage system consisting of an upper and lower 6 in. dia., open jointed, vitrified pipe, connected to a 12 in. dia. pipe and then into a weir chamber located at the downstream toe at maximum section. At the time of the inspection most of the water discharging through the toe drain was bypassing the pipe and flowing around it instead of through it. Seepage was estimated to be approximately 5 gpm. (See Photo Nos. 4 and 5, Appendix C.)

c. Appurtenant Structures. The lined spillway channel at the right abutment of the dam has a 10 ft. wide ogee crested weir with training walls extending 3 ft. above the spillway crest to elevation 492 MSL. From there the spillway opening becomes a modified V-notch and rises to the top of dam, elevation 496 MSL, on 2½ horizontal to 1 vertical unprotected earthen side slopes. In the past, stoplogs were installed on top of the weir, but according to Water and Sewer Department officials this practice was ended in 1972 (Appendix B). The approach channel and discharge channel are constructed of masonry walls with the channel floors being cobblestone block paving laid in cement mortar. The discharge channel training walls are about 2 ft. high. The training walls both left and right of the channel have been parged with mortar. This parging is weathered and minor deterioration has occurred. Additionally, the concrete cap of the right training wall is deteriorated (see Photo Nos. 6, 7 and 8, Appendix C).

Tree growth has become established in the downstream spillway chute (see Photo No. 9, Appendix C).

The spillway chute is carried perpendicular to the dam axis for about 150 ft. downstream of the spillway crest. There it curves towards the center of the valley at about a 45 degree angle. It outlets approximately 160 ft. beyond the downstream toe of the dam into Porter Brook. The hand-placed stone and concrete training wall constructed on the left bank of Porter Brook directly opposite the end of spillway chute is in good condition (see Photo No. 10, Appendix C).

The outlets for this project are located at the midpoint of the dam. According to plans on file with the City of Manchester (Appendix B), there is a 24 in. dia. outlet pipe leading from the wet well with gatehouse, which discharges into Porter Brook. However, field observations and discussions with City officials indicate that there is also a 14 in. dia. gravity pipe from the gatehouse to Porter Reservoir and that a T-Stem is located in the line. This T-Stem pipe also discharges into the Porter Brook at the toe of Howard Reservoir. Both the 24-in. dia. blowoff pipe and the 14 in. dia. T-Stem pipe emanate from a headwall at the toe of the dam. At the time of inspection, there was no flow from the 14 in. dia. pipe and about 20 gpm was flowing from the 24 in. dia. blowoff. Both outlet pipes are controlled by gates operated from the top of the wet well shaft.
The gatehouse at the crest of the dam is over the wet well. A 20 in. dia. low level inlet pipe at elevation 454 MSL and a 14 in. dia. high level inlet pipe at elevation 469 MSL are controlled by two gates located in the gatehouse. Manchester City officials indicated that all gates were operable and were regularly used or had been tested within the past year.

d. Reservoir Area. The shoreline of the reservoir upstream of the dam appeared stable. A highway embankment has been constructed across the southern rim of the reservoir. No evidence of slides or other problems were noted.

e. Downstream Channel. Porter Brook flows from Howard Reservoir through a residential area to its confluence with Birch Mountain Brook about 2 miles downstream of the dam. There they form the Hop Brook, a tributary of the Hockanum River, which flows into the Connecticut River. There are about 15 homes along the downstream channel which would be inundated by high flows. The Highland Park School, as well as the Porter Street crossing over Porter Brook, would also be inundated. The concrete culvert carrying Porter Street over Porter Brook is only about 9 ft. long and 6 ft. high.

3.2 Evaluation

The visual inspection has adequately revealed key characteristics of the dam as they may relate to its stability and integrity. The dam and appurtenant works are judged to be in good condition.

On the downstream slope brush growth is becoming well established and there is evidence of seepage along the toe.

The top 4 ft. of the spillway opening through the dam embankment is a modified V-notch with 2½ to 1 unpaved side slopes. Outflows through the spillway exceeding a depth of 3 ft. and 214 cfs would probably begin eroding the top 4 ft. of the dam, thereby greatly increasing the possibility of the dam being breeched before the reservoir level reached the top of the dam. The training wall of the downstream chute are only 2 ft. high and would probably be overtopped during periods of high outflow. The concrete cap of the right training wall is spalled and deteriorated.

9

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Howard Reservoir and Dam is operated by personnel of the City of Manchester, Water and Sewer Department. Reservoir operation entails mainly the release of stored water from the reservoir to either Porter Reservoir or to the City's water treatment and distribution facilities. Day-to-day regulation of the outlet valve is not required. However, the reservoir is visited at least once a day by reservoir patrolmen. No documented operating procedures have been prepared.

4.2 Maintenance of Dam

Little maintenance is accomplished except for periodic cutting of brush growth on the crest of the dam and embankment. No documented maintenance instructions have been prepared.

4.3 Maintenance of Operating Facilities

The gate valve operating mechanisms require periodic maintenance to keep them serviceable.

4.4 Description of Any Warning System in Effect

No warning system is in effect at Howard Reservoir Dam.

4.5 Evaluation

Although little is known about the construction of the facility, it has simple operating devices and, as such, requires no detailed operating procedures. Maintenance involves periodic growth removal from the embankment and surveillance regarding seeps, slope damage, animal burrows, etc. The outlet operating gates require checking and repairs should be made as necessary. A formal warning system should be developed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General. Howard Reservoir Dam is an earthfill embankment impounding a normal storage of about 329 acre-ft. to spillway crest, with provision for an additional 149 acre-ft. of capacity in its surcharge space to the top of the dam. It is basically a low surcharge - low spillage facility used for water supply purposes. The spillway is capable of discharging about 967 cfs. with surcharge to the top of the dam. The general topographic characteristic of the 0.86 sq. mi. (550 acres) drainage basin is best described as rolling terrain, which rises from 489.0 MSL at the spillway crest to about elevation 810 MSL. The area is generally forested but has several residential developments.

b. Design Data. There is no design data available for this dam.

c. Experience Data. No records are available in regard to past operation of the reservoir, nor of surcharge encroachments and flows through the spillway. The maximum past inflows are unknown.

d. Visual Observations. There are no present evidences either along the reservoir or in the downstream channel to indicate high water levels or signs of any major spillway outflows. No one contacted could recollect any such occurrences.

e. Test Flood Analysis. Reservoir area and capacity curves and tables, for use in flood routings, are shown on Fig. 1, Sheets D-1 and D-2, Appendix D. For determining surface areas and surcharge capacities, planimetered areas were taken from contours delineated on USGS 2,000 ft. per in. quadrangle sheets.

The test flood chosen to evaluate the hydrologic and hydraulic capacity of Howard Reservoir Dam was selected in accordance with the criteria presented in the Recommended Guidelines for Safety Inspection of Dams. Since this dam is classified as intermediate in size with a high hazard potential, a test flood of magnitude corresponding to the Probable Maximum Flood (PMF) was selected for the evaluation.

Precipitation data were obtained from Hydrometeorological Report No. 33, which for the Connecticut area approximates 24.0 in. of 6 hour point rainfall over a 10 square mile area. This value was then reduced by 20 percent to allow for basin size, shape and fit factors. The 6 hour rainfall was distributed into one hour incremental periods as suggested in COE Publication EC1110-2-1411. A constant loss factor of 0.1 in. per hour was deducted from the precipitation values to give the excess rainfall used to prepare an inflow hydrograph.

A triangular incremental unitgraph was assumed for the inflow hydrographs, using a computed lag time value of 1.7 hours to derive a time-to-peak for the triangular hydrograph of 1.8 hours (see computations on Sheets D-3, D-4 and D-5, Appendix D). A PMF inflow hydrograph is shown on Fig. 2, Sheet D-6, Appendix D, indicating a peak inflow of about 2,600 cfs or a CSM of about 2,990.

Discharge tables and curves for the spillway and for over the top of the dam
are shown on Sheets D-7 and D-8 and Fig. 3 Sheet D-9, Appendix D. The spill-
way capacity at top of dam, elevation 496.0 MSL, is 967 cfs.

Flood routings were performed for both 1/2 and full PMF. The discharge capacity
of the 24 in. dia. blowoff pipe was not considered. Results of the flood
routings are shown on Sheets D-10, D-11 and D-12, and are summarized as follows:

Flood Magnitude	Max. Disch. cfs	Max. Res.El. ft.MSL	Max. Head Over Dam ft.
1/2 PMF	950	496.0	0.0
PMF	2,300	496.7	0.7

From the above table, it can be seen that the project will not pass the test
flood without overtopping the dam by 0.7 ft. The project, however, can handle
42% of the PMP flood without overtopping the dam. It should be noted that,
while the spillway opening could handle about 42% of the test flood, it is
doubtful the downstream spillway channel would also handle such a flow. The
2 ft. high masonry training walls lining the spillway chute would probably
be overtopped during high flows, which could result in erosion of the down-
stream toe of the dam, a washout of the chute and possible undermining of the
dam embankment.

The use of stoplogs would decrease spillway capacity and therefore they should
not be used in the future.

f. Dam Failure Analysis. As discussed in para. e, the dam would be over-
topped by the PMF test flood. Also, a breach owing to structural failure of the
dam by piping or sloughing is a possibility. A breach was assumed with the water
level at the top of dam, using "rule of thumb" criteria suggested in the NED
March 1978 Guidance Report for the breach analysis. With a breach width of 40
percent of the dam length at mid-height or 105 feet, an outflow of about 56,900
cfs would be realized. (See Sheets D-13 thru D-21, Appendix D)

Stage discharge computations show that in the first 1,500 ft. reach below the
dam a flood depth of up to 20 ft. would prevail. This is about 14 ft. higher
than the stage resulting from full spillway discharge of 970 cfs just prior
to failure. In the next 1,500 ft. reach, a stage of about 18 ft. would prevail,

or about 13 ft. higher than the stage caused by the full spillway discharge. There are no structures in the first two reaches below the dam. However, in the third reach are located the Highland Park School, 6 homes, and the Porter Street crossing of Porter Brook, all of which would sustain damage by flood waters resulting from a breach of the dam. The stage in the third reach is estimated to be about 12 ft. for the breach flow or about 8 ft. higher than would be realized from the full spillway discharge. In the next 2,000 ft. long reach beyond Porter Street the breach stage would be about 10 ft. or about 7 ft. above the anticipated full spillway discharge stage. In the next 3,000 ft. long reach the stage would rise from a depth of about 4 ft. to a depth of 9 ft. In the later two reaches are located 9 houses that would sustain major damage due to the rising waters. Approximately 2 miles downstream from the dam the flood depth is estimated to be below 9 ft. and appears that no further significant damage would result from high waters. Hence, a total of about 15 homes, the Highland Park School, and Porter Street crossing of Porter Brook would be damaged. Delineated on Figure 5, sheet D-22, Appendix D, are the areas which would be flooded as a result of a breach of the dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual Observations.** The field investigation revealed no significant displacements or distress that would warrant the preparation of stability computations based on assumed soil properties and engineering factors.

b. **Design and Construction Data.** No plans or calculations of value to a stability assessment are available for the dam.

c. **Operating Records.** There are no operating records of any significance to structural stability.

d. **Post Construction Changes.** There are no records of any post construction changes made to the dam over the course of its history.

e. **Seismic Stability.** The dam is located in seismic Zone No. 1 and in accordance with recommended Phase I Guidelines does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMEDNDATIONS & REMEDIAL MEASURES

7.1 Dam Assessment.

    a. Condition. On the basis of the Phase I visual examination, Howard Reservoir Dam appears to be in good condition at the present time. The minor deficiencies revealed indicate that further investigations are required. The principal items of concern are the seepage at the toe of the dam, the unprotected side slopes of the spillway and the low spillway chute training walls. There is also a considerable amount of brush growth on the downstream slope of the dam.

    b. Adequacy of Information. The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from a standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgment.

    c. Urgency. The recommendations and remedial measures enumerated below should be implemented by the owner within two years after receipt of this Phase I inspection report.

    d. Need for Additional Investigations. Additional investigations are required as recommended in Para. 7.2.

7.2 Recommendations

It is recommended that the owner should retain the services of a competent registered professional engineer to make investigations and studies of the following, and if proved necessary, to design appropriate remedial works:

(1) An in-depth assessment concerning the spillway adequacy, the potential for overtopping and possible failure, ways of increasing the total discharge capacity of the dam, and the use of stoplogs.

(2) Determine whether the spillway training walls should be raised to the level of the top of dam.

(3) Review flow conditions in the downstream spillway chute and determine whether modifications are required to forstall possible overtopping of the walls.

7.3 Remedial Measures

    a. Operation and Maintenance Procedures.

(1) Brush growth on the downstream slope of the dam should be removed and controlled on a regular basis.

(2) Tree growth should be removed from the spillway channel.

(3) Backfill the rodent burrow near the toe of the downstream slope and monitor the embankment for other burrows.

(4) Repair all spalled and deteriorated concrete.

(5) Stoplogs on the spillway crest should not be used until all the above recommendations and all other remedial measures have been implemented.

(6) Seepage quantity and clarity from the toe drains and wet area at the downstream toe should be monitored monthly during periods of high reservoir level.

(7) A formal surveillance and flood warning plan should be developed, including round-the-clock monitoring during heavy rainfall.

(8) Procedures for a biennial periodic technical inspection of the dam and appurtenant works should be instituted.

7.4 Alternatives

There are no practical alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Howard Reservoir Dam

DATE 9 April & 10 May 1979

TIME 9:00 a.m.

WEATHER Rain (4/9) - Sunny (5/10)

W.S. ELEV. 489.1 U.S. N/A DN.S.

PARTY:

1. Peter B. Dyson
2. Pasquale E. Corsetti
3. Roger F. Berry
4. Carl J. Hoffman
5. William S. Zoino

6. Robert Young
7. Walter Senkow
8.
9.
10.

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Hydrologic	Roger F. Berry	
2. Hydraulic/Structures	Carl J. Hoffman	
3. Soils and Geology	William S. Zoino	
4. General Features	Peter B. Dyson	
5. General Features	Pasquale E. Corsetti	
6.		
7.		
8.		
9.		
10.		

PERIODIC INSPECTION CHECKLIST

PROJECT Howard Reservoir Dam   DATE 9 April & 10 May 1979

PROJECT FEATURE Embankment   NAME W. Zoino

DISCIPLINE Soils/Structures   NAME C. Hoffman

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	496.0 MSL
Current Pool Elevation	489.1 MSL
Maximum Impoundment to Date	Unknown
Surface Cracks	None Evident
Pavement Condition	N/A
Movement or Settlement of Crest	None Evident
Lateral Movement	None Evident
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None Evident
Trespassing on Slopes	Lg. rodent hole, at d/s toe, about 300' from left abut.
Sloughing or Erosion of Slopes or Abutments	None Evident
Rock Slope Protection - Riprap Failures	U/S face hand-placed minor displacement due to ice jacking
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Seepage at toe about 400' from left abut.
Piping or Boils	None Evident
Foundation Drainage Features	Toe drains
Toe Drains	Functioning
Instrumentation System	None

PERIODIC INSPECTION CHECKLIST

PROJECT Howard Reservoir Dam   DATE 9 April & 10 May 1979

PROJECT FEATURE Gate House   NAME C. Hoffman

DISCIPLINE Structures   NAME

AREA EVALUATED	CONDITIONS

OUTLET WORKS - CONTROL TOWER

a. Concrete and Structural

General Condition	Fair
Condition of Joints	Fair-minor deterioration
Spalling	Yes - minor
Visible Reinforcing	None Visible
Rusting or Staning of Concrete	Minor
Any Seepage or Efflorescence	None Visible
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	N/A
Cracks	Minor surface cracks
Rusting or Corrosion of Steel	N/A

b. Mechanical and Electrical   N/A

    Air Vents

    Float Wells

    Crane Hoist

    Elevator

    Hydraulic System

    Service Gates

    Emergency Gates

    Lighting Protection System

    Emergency Power System

    Wiring and Lighting System in Gate Chamber

PERIODIC INSPECTION CHECKLIST

PROJECT __Howard Reservoir Dam__   DATE __9 April & 10 May 1979__

PROJECT FEATURE __Spillway__   NAME __C. Hoffman__

DISCIPLINE __Hydraulics/Structures__   NAME _____

AREA EVALUATED	CONDITIONS

OUTLET WORKS - SPILLWAY WEIR, APPROACH
AND DISCHARGE CHANNELS

a. Approach Channel

General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Granite slope paving

b. Weir and Training Walls

General Condition of Concrete	Fair
Rust or Staining	Yes
Spalling	Yes - along cap of right training wall
Any Visible Reinforcing	No
Any Seepage or Efflorescence	Yes
Drain Holes	Yes

c. Discharge Channel

General Condition	Fair
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Yes
Floor of Channel	Granite slope paving
Other Obstructions	Trees & brush growing in channel

APPENDIX B

ENGINEERING DATA

Overflow at Howard Reservoir
— Cheney Brothers —
So Manchester Ct
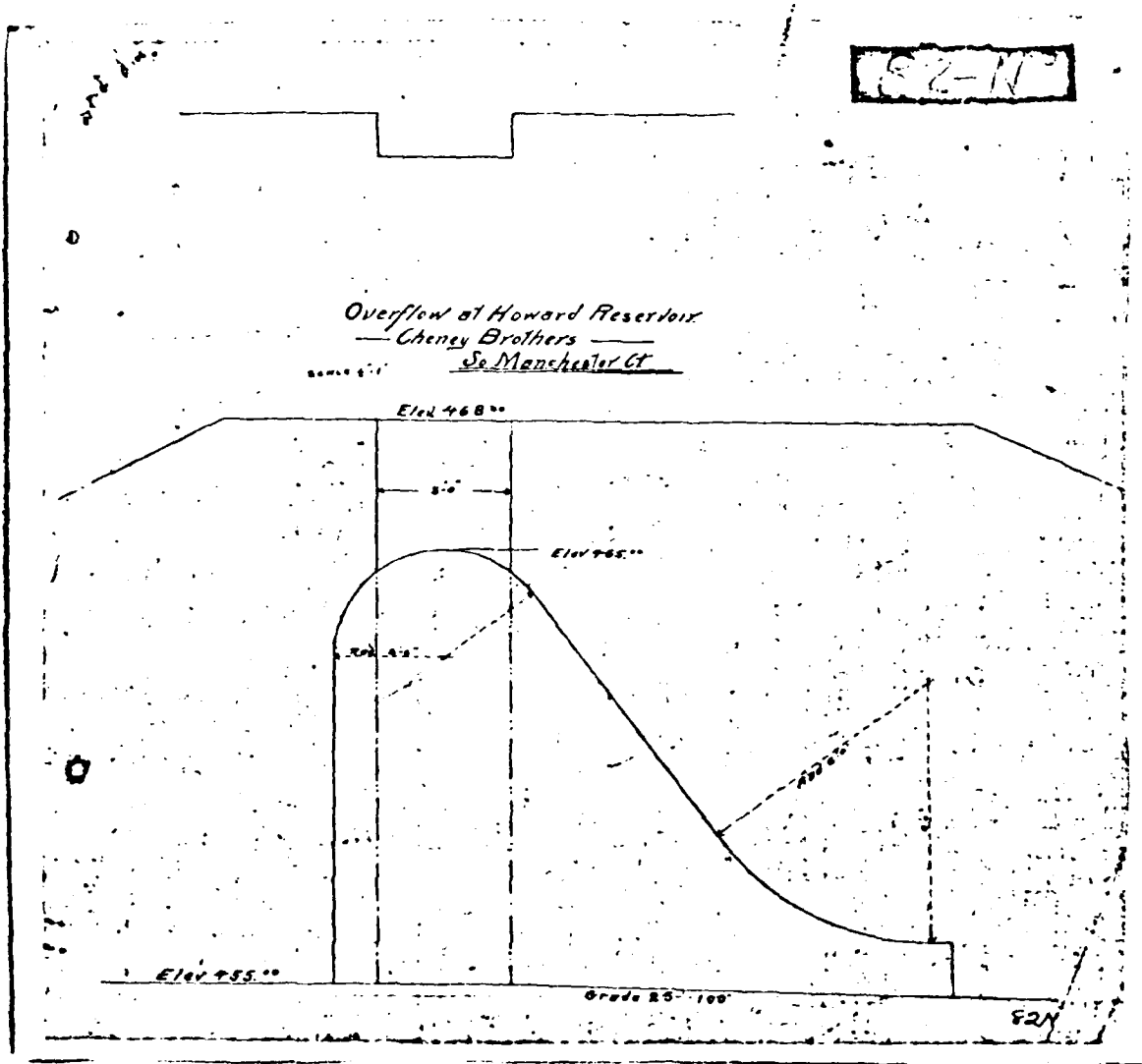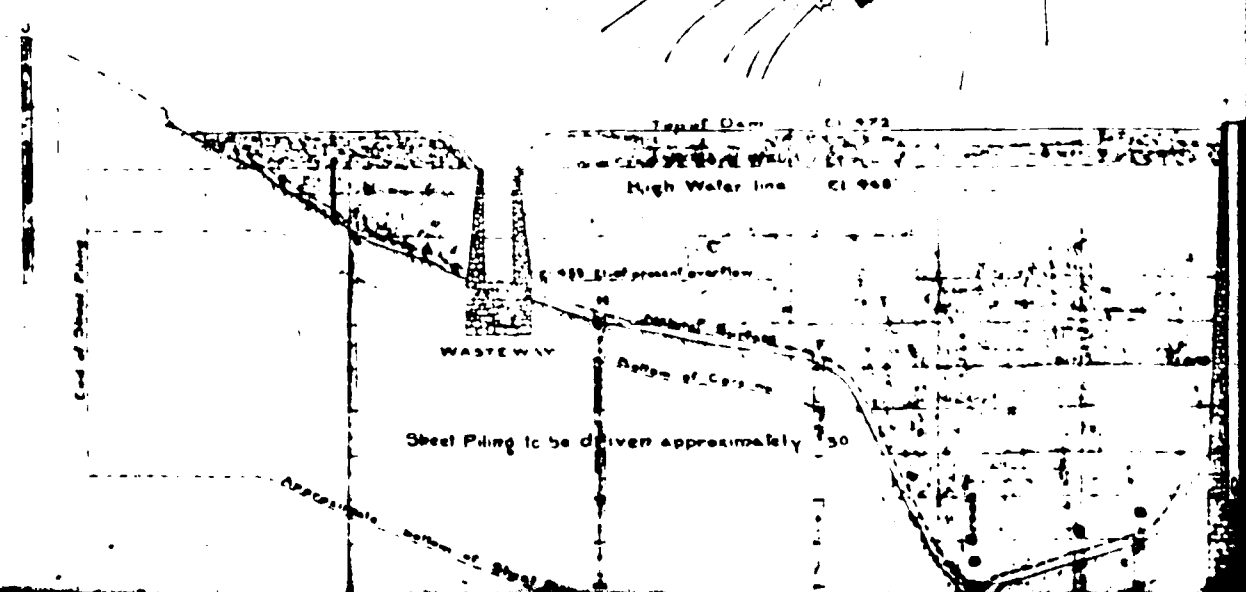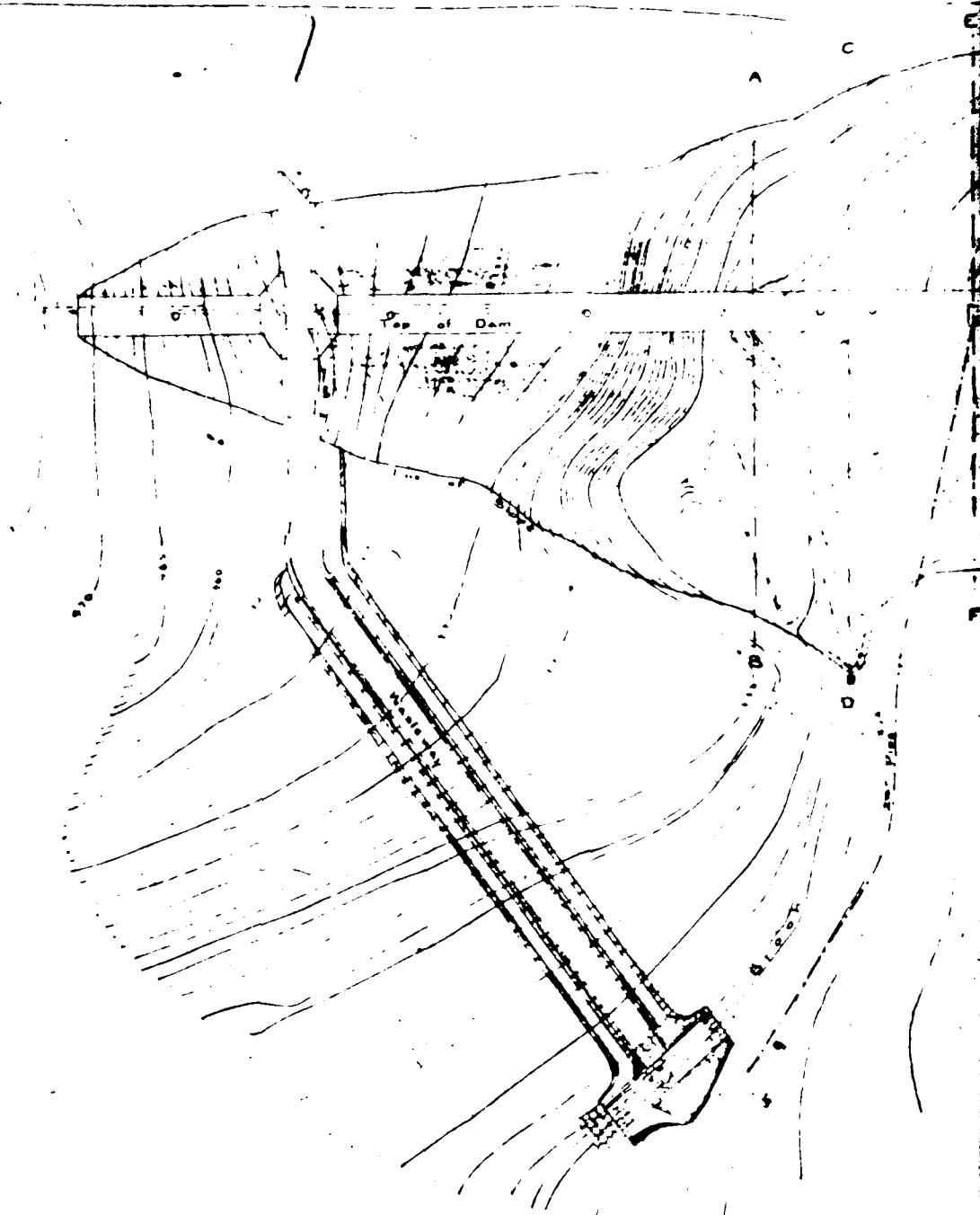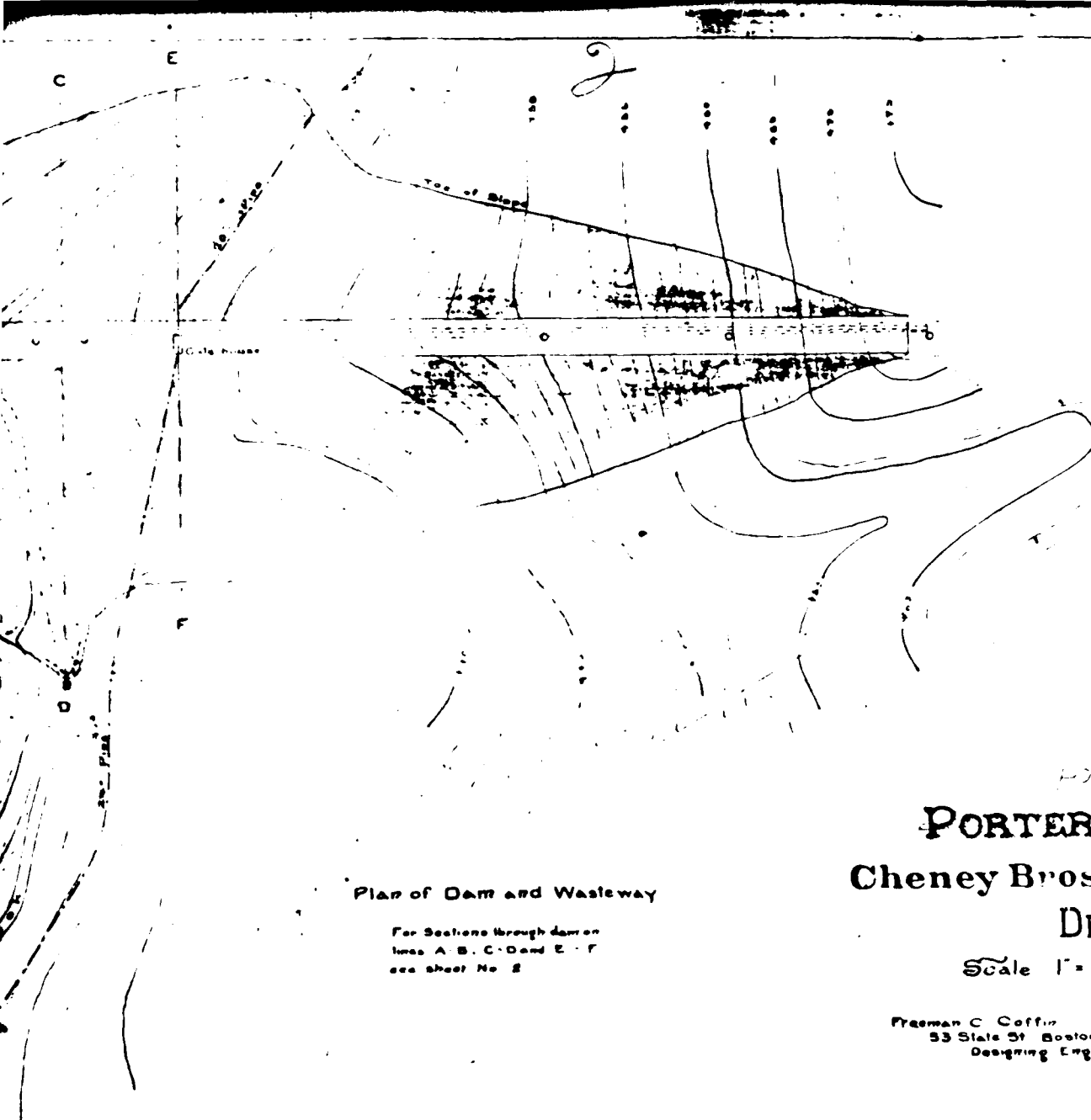
Elev 468

Elev 465

Elev 455

Grade 25 : 100

82N

Top of Dam

High Water line   El 968

WASTEWAY

Sheet Piling to be driven approximately 50

Plan of Dam and Wasteway

For Sections through dam on
lines A-B-C-D and E-F
see sheet No 2

PORTER BROOK RE
Cheney Bros. South Man
DRAWINGS OF DA

Scale 1" = 30

Freeman C. Coffin
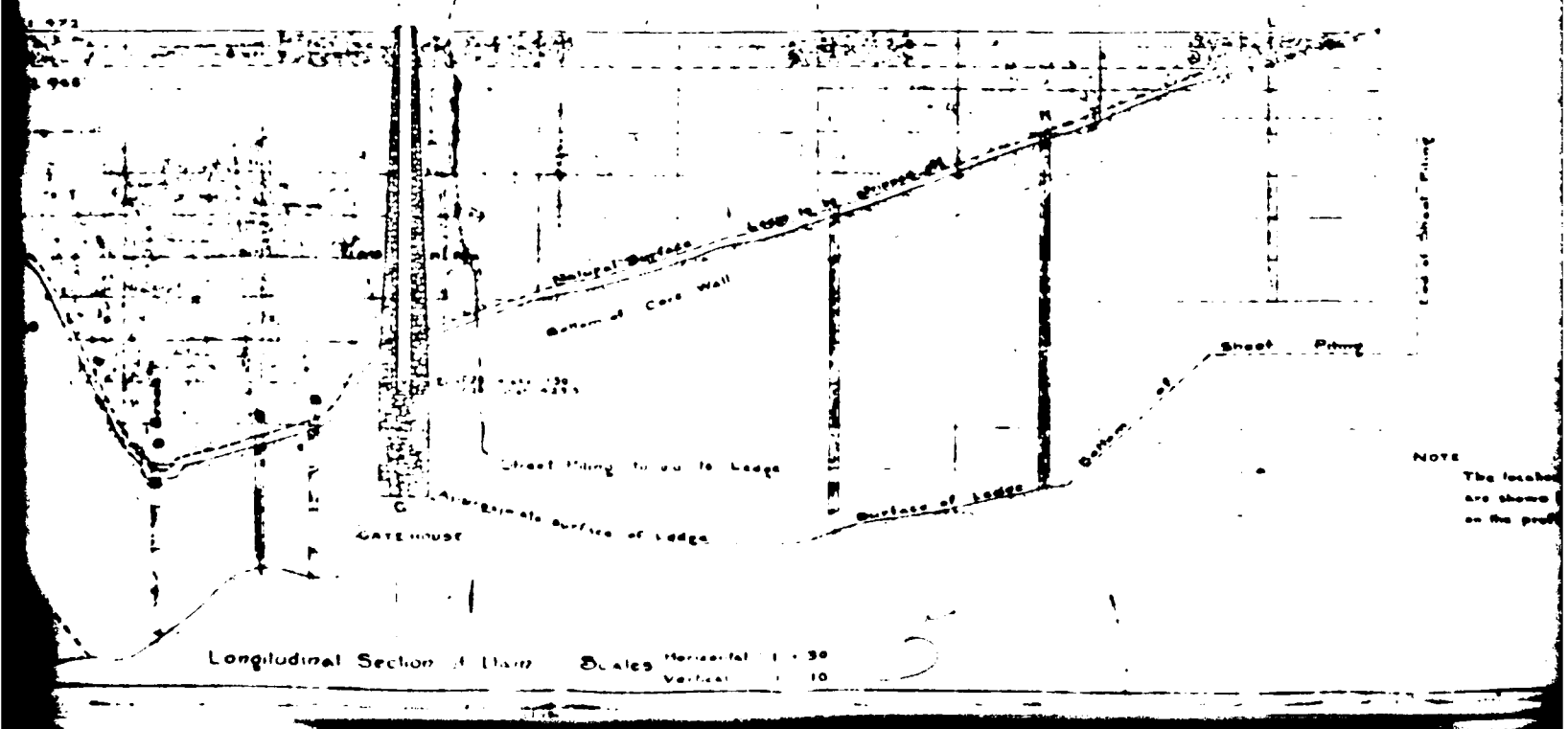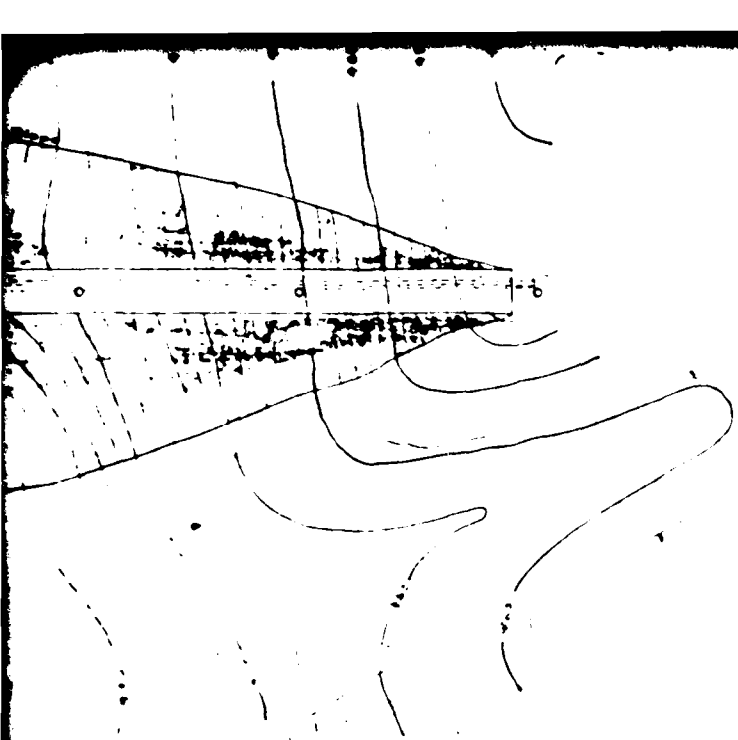53 State St Boston
Designing Engineer

GATE HOUSE

Sheet Piling to go to Ledge

Approximate Surface of Ledge

Surface of Ledge

Bottom of Core Wall

and Wasleway

brough dam on
Dam E F

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM
Scale 1" = 30   5.2   July. 1902

Freeman C. Coffin
53 State St Boston
Designing Engineer
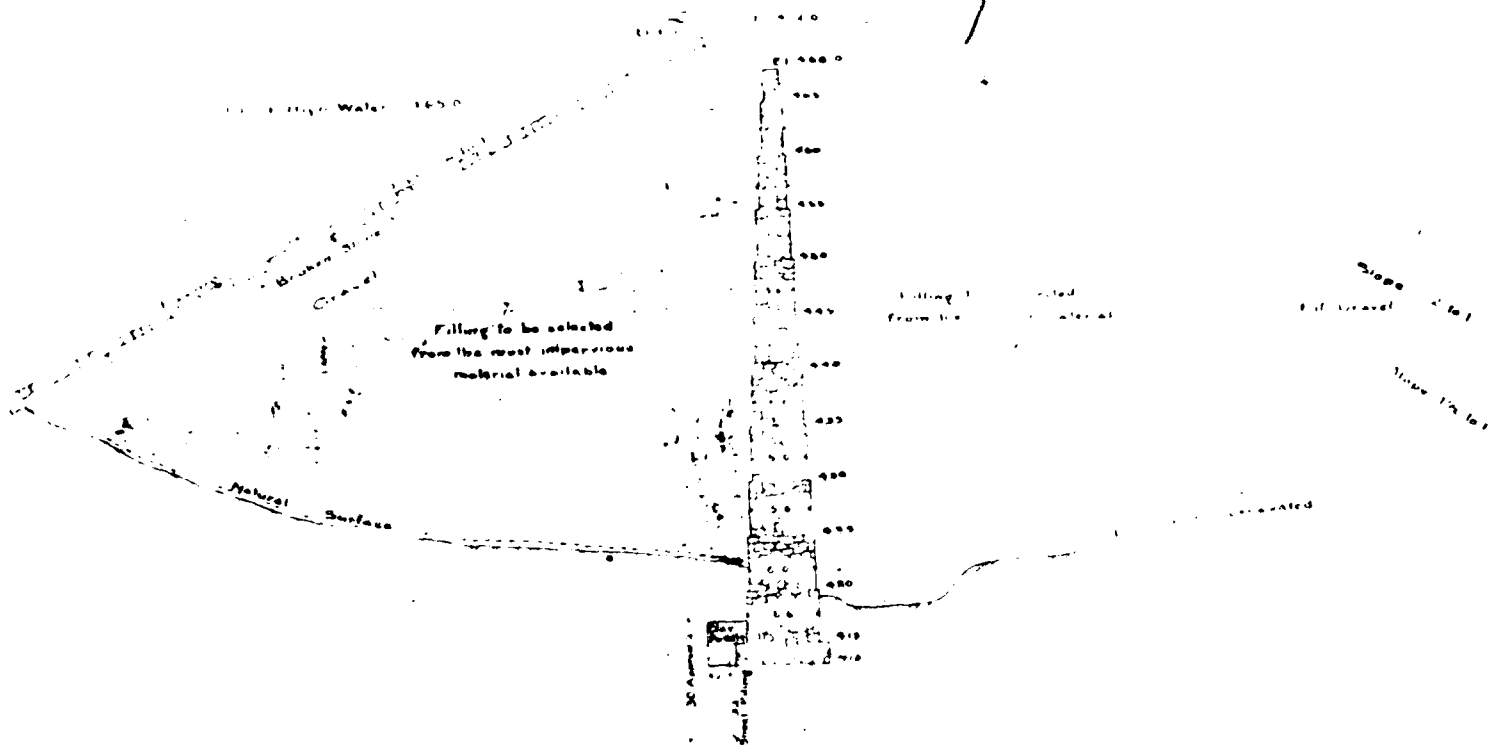
Desmond Fitz Gerald
Boston
Consulting Engineer

End of Sheet Piling

Sheet Piling

NOTE
The location of Test Wells
are shown by the letters
on the profile
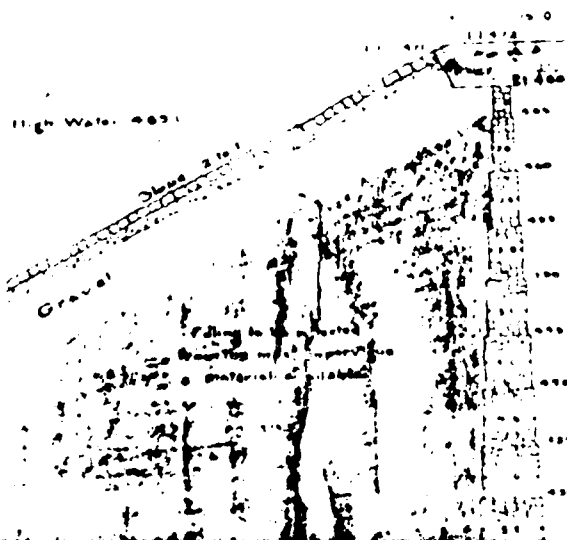
HOWARD RESEVOIR DAM
(PORTER RESEVOIR DAM)

Plan of Dam

Top of Dam   El 972

High Water line   El 968

Wasteway

Steel Piling to be driven approximately 50

Surface of Ledge   Longitudinal

Plan of Dam and Wasteway

For Sections through dam on
lines A B C D and E F
see sheet No 2

PORTER BR

Cheney Bros. Sou

DRAWIN

Scale 1" = 30

Freeman C Coffin
53 State St Boston
Designing Engineer

Longitudinal Section of Dam   Scales Horizontal 1 : 30
                                      Vertical : 10

and Wasteway

through dam on
Dam E F
E

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM

Scale 1" = 30'   July, 1902

Freeman C. Coffin
33 State St Boston
Designing Engineer

Desmond Fitz Gerald
Boston
Consulting Engineer

End of Sheet Piling

Sheet Piling

Surface of Ledge
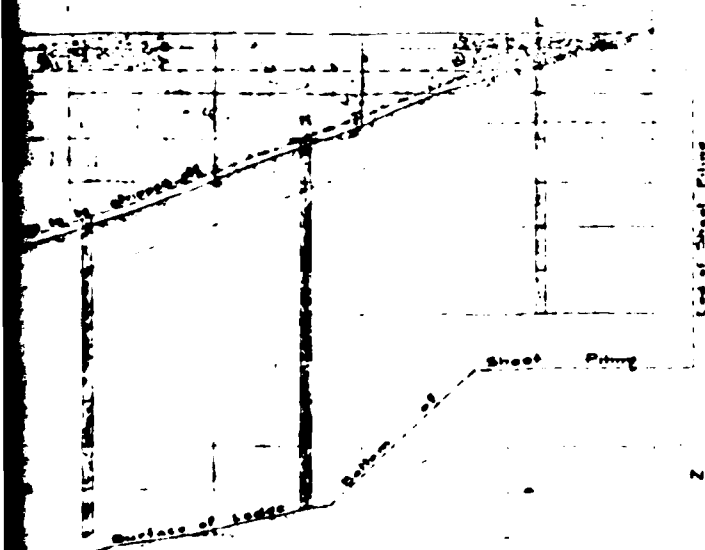
NOTE
The location of Test Wells
are shown by the letters
on the profile

HOWARD RESEVOIR DAM
formerly (PORTER RESEVOIR DAM)
MANCHESTER
DRAWING No. 1

Filling to be selected
from the most impervious
material available

Natural Surface

Section on line   A - B. See Sheet No 1

Section through Collector around
the toe of dam   Scale ½" = 1

High Water 483?

Gravel

Filling to be selected
from the coarser material

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester,
DRAWINGS OF DAM

Scale ⅛" 1   №2   July. 1902

Freeman C. Coffin
53 State St. Boston
Designing Engineer

Desmond Fitz Gerald
B.
Consulting

Loam taken
from the
Reservoir

E.L. High Water 165

Gravel

Natural

Filling to be selected
from the coarser material

Gravel

Loam to be excavated

20 Pipe   20 Pipe

To Ledge

**Section through Dam on center line
of Gate House**

See Sheet No. 1

Plan of a portion of C
showing
Outlet pipes and Weir

Toe of Embankment

Upper Collector

Lower Collector

12 Pipe

Gravel

To open the
Reservoir

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM

Scale : ⅛″: 1   №2   July, 1902

Freeman C. Coffin
53 State St. Boston
Designing Engineer

Desmond Fitz Gerald
Boston
Consulting Engineer

Filling to be selected
from the coarser material

Pit Gravel

Loam to be excavated

20 Pipe

30 Pipe

To Ledge

Section through Dam on center line
of Gate House
See Sheet No 1

Plan of a portion of Collector
showing
Outlet pipes and Weir Chamber

Toe of Embankment

Upper Collector

Lower Collector

12 Pipe

Weir Chamber

Section on line A - B. See Sheet No 1

Section through Collector around
the toe of dam Scale ½" = 1

High Water 4651

Slope 2 to 1

Gravel
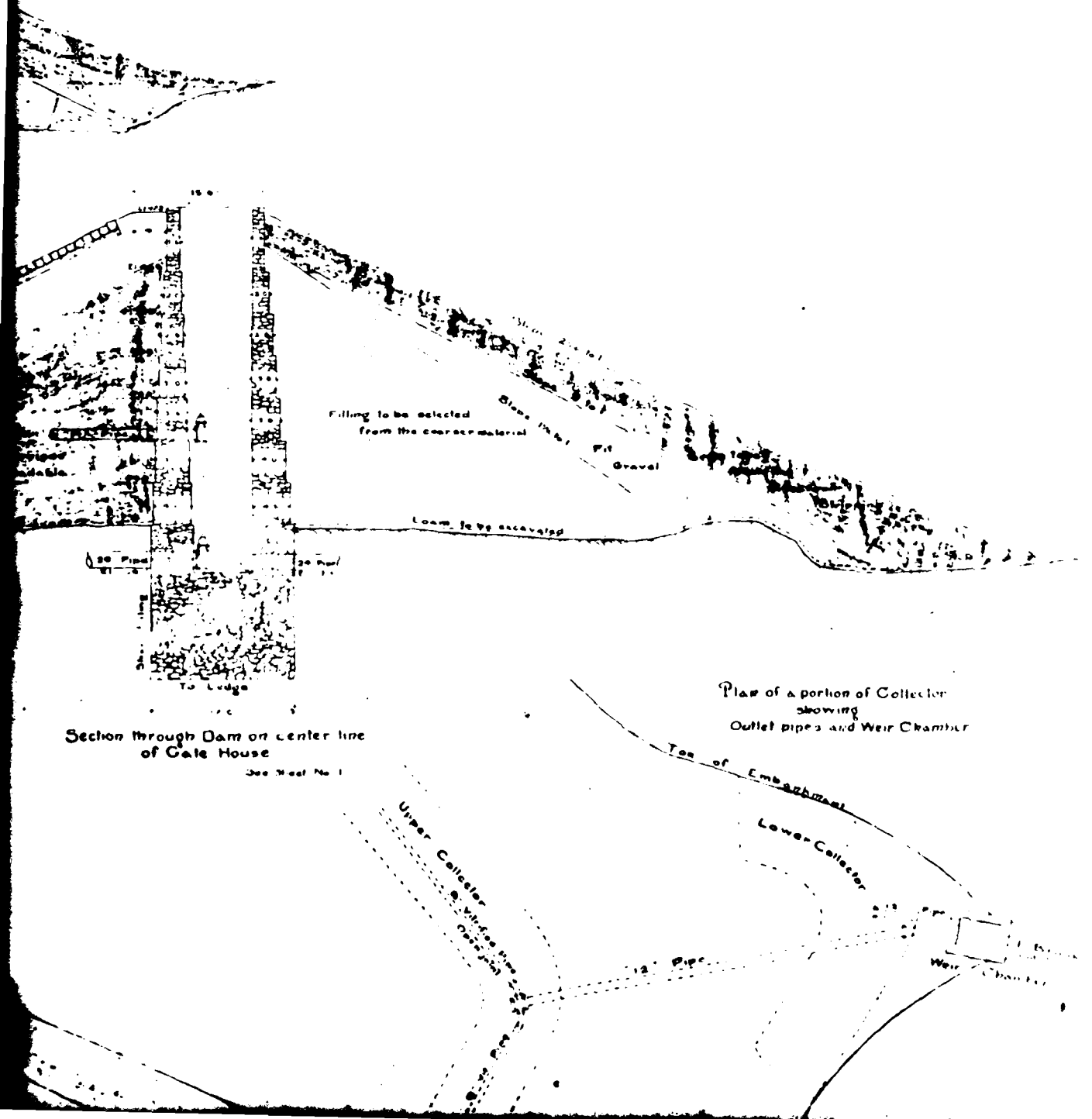
Filling to be selected
from the most impervious
material available

Filling to be selected
from the coarsest material

Natural Surface

Section through Dam on line C   D

Cheney Bros. South
DRAWINGS
Scale ⅛" 1

Freeman C. C.
53 State St. Boston
Designing Engineer

Loam layer
from the
Reservoir
strippings

Stone ½ to 1
Fill Gravel

El High Water 165

Gravel

Filling to be selected
from the coarser material

Stone ½ to 1
Pit Gravel

Natural Surface

Loam to be excavated

20 Pipe   20 Pipe

To Ledge

Section through Dam on center line
of Gate House

See Sheet No 1

Stone ½ to 1   Gravel

To be selected
coarser material

from the
Reservoir
Stripping

Upper Collector

Loam to be excavated

Collector

Dam on line C D

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM

Scale 1/6"=1'   No 2   July. 1902

Freeman C. Coffin
53 State St. Boston
Designing Engineer

Desmond FitzGerald
Boston
Consulting Engineer

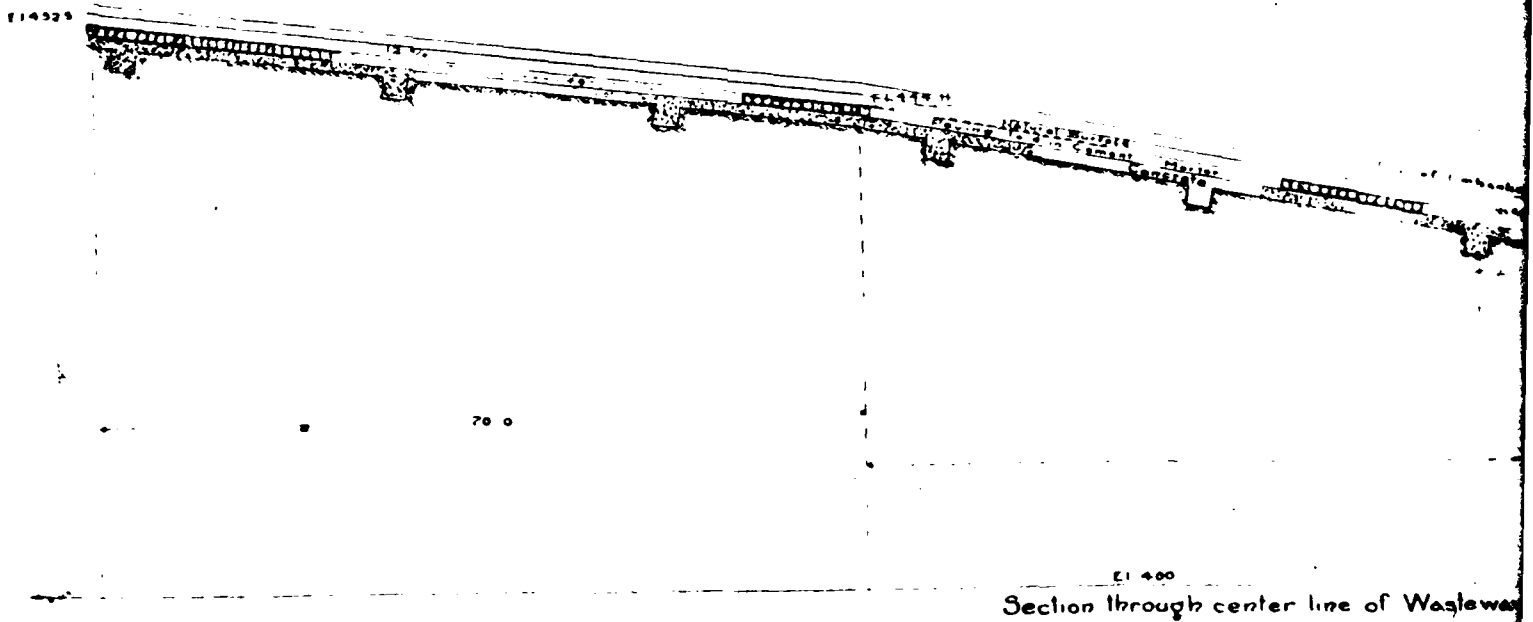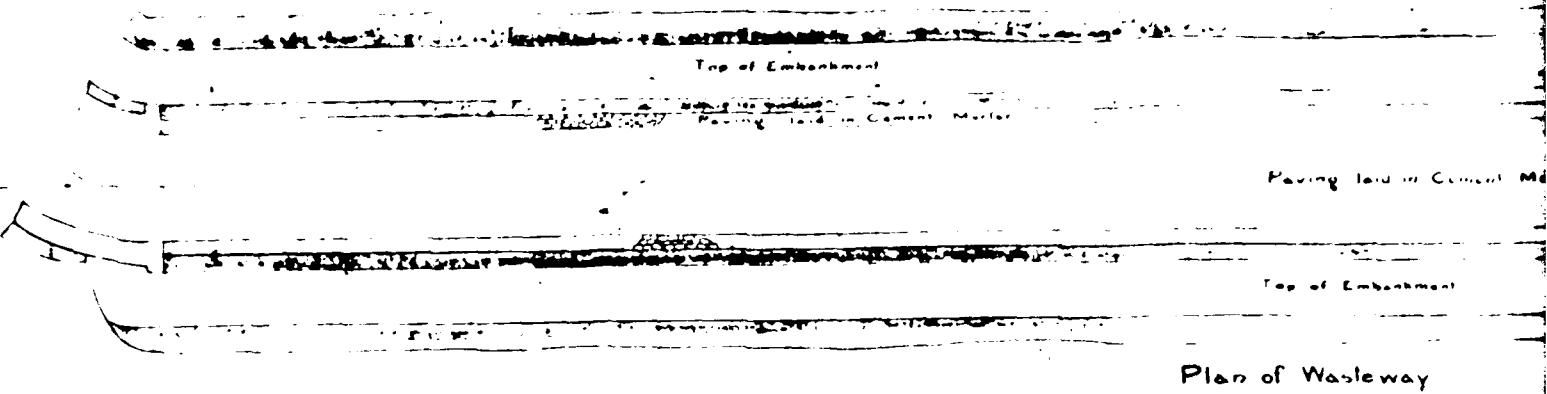

Filling to be selected from the nearest material

Pit Gravel

Loam to be excavated

20 Pipe

To Ledge

Section through Dam on center line of Gate House

See Sheet No 1

Plan of a portion of Collector showing Outlet pipes and Weir Chamber

Toe of Embankment

Upper Collector

Lower Collector

12" Pipe

Weir Chamber

Collector
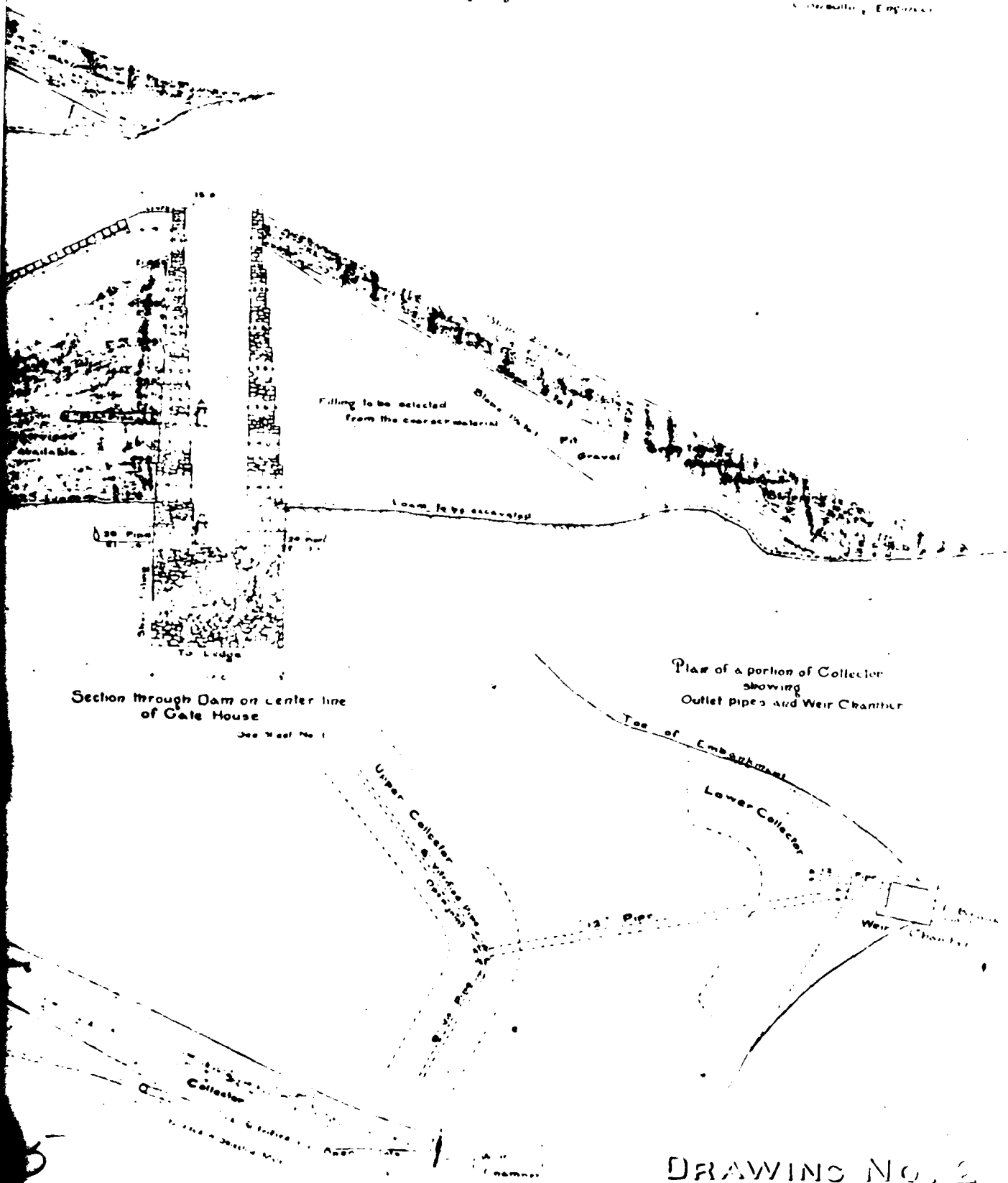
DRAWING No. 2

Section across Wasteway on line K L

Plan of Wastew

Section on line O P

Section on line M N
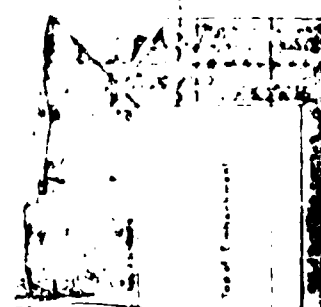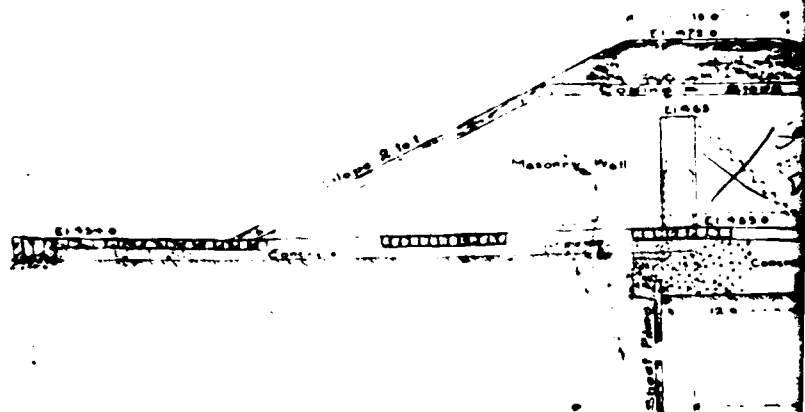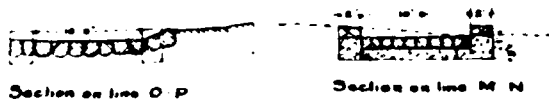
Section through ce
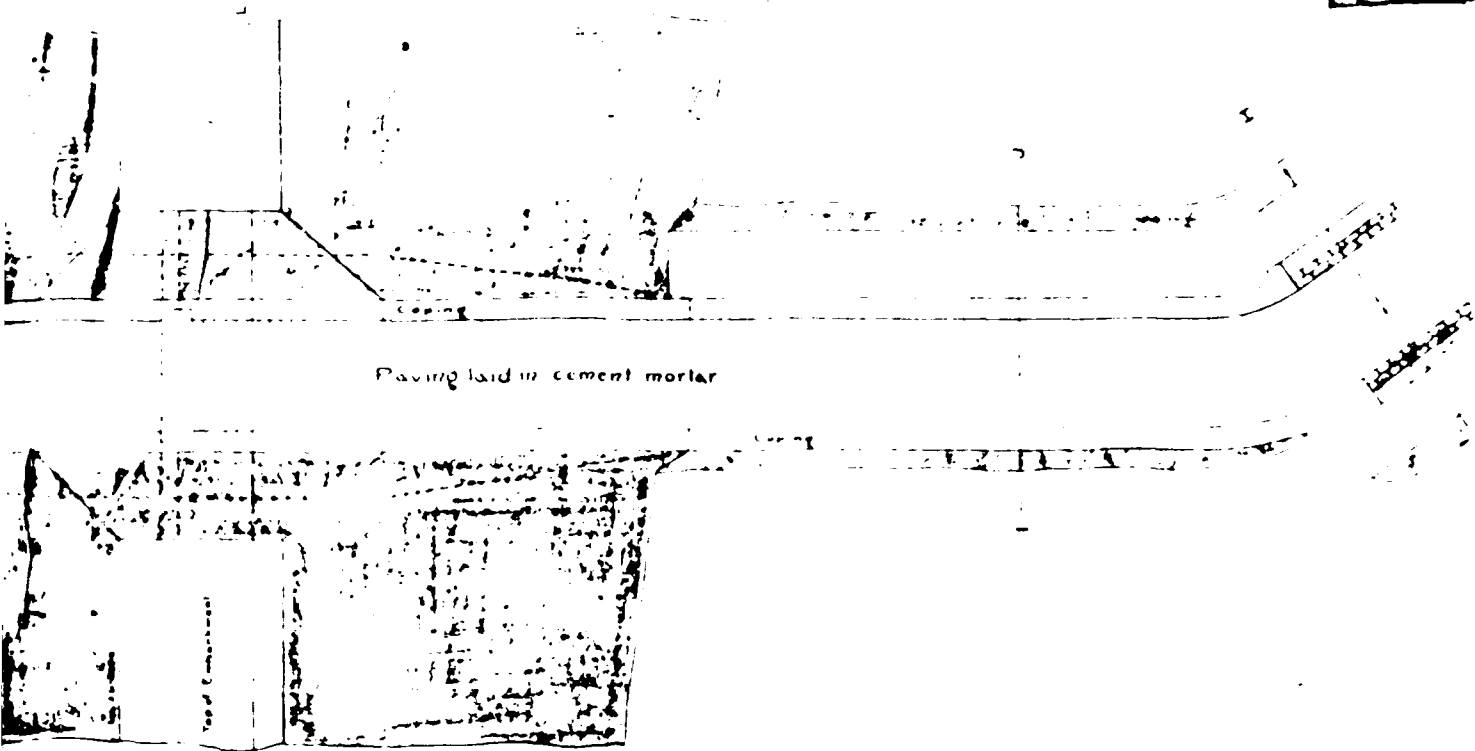
Paving laid in cement mortar

Plan of Wasteway

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM
DETAILS OF WASTEWAY

Scale ⅛"=1'   —   July, 1902.

Freeman C. Coffin
53 State St Boston
Designing Engineer

Desmond FitzGerald
Boston
Consulting Engineer
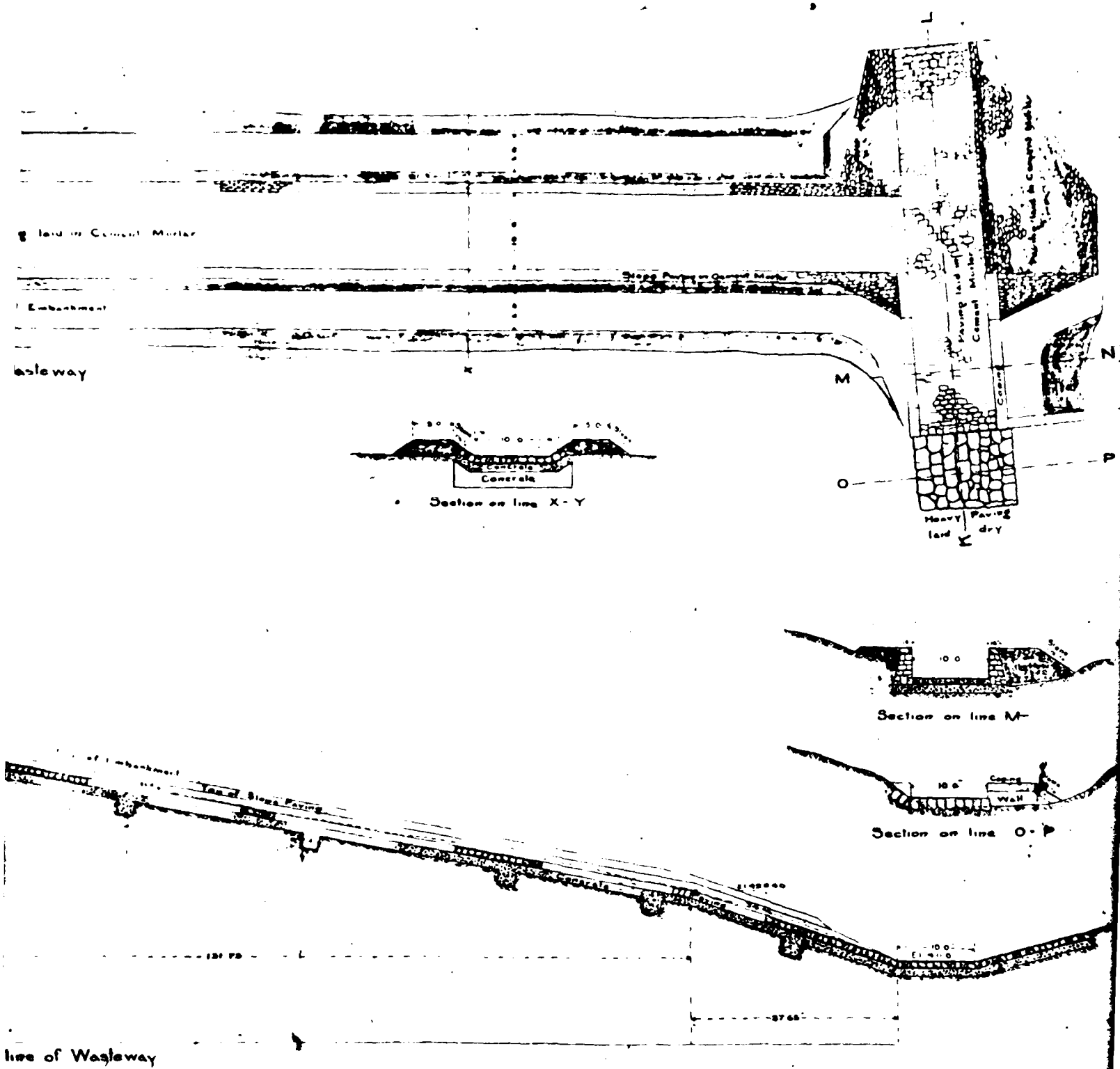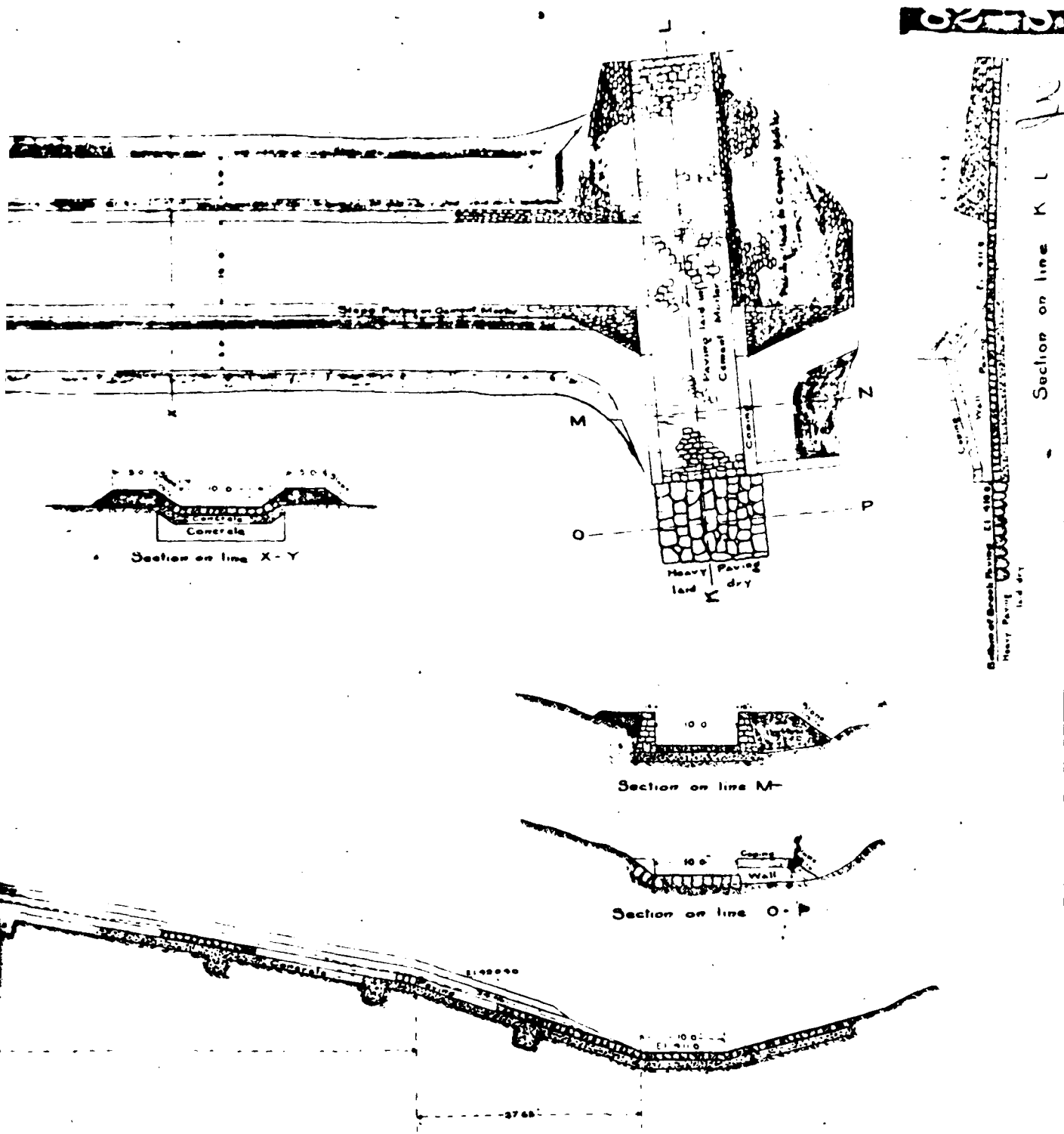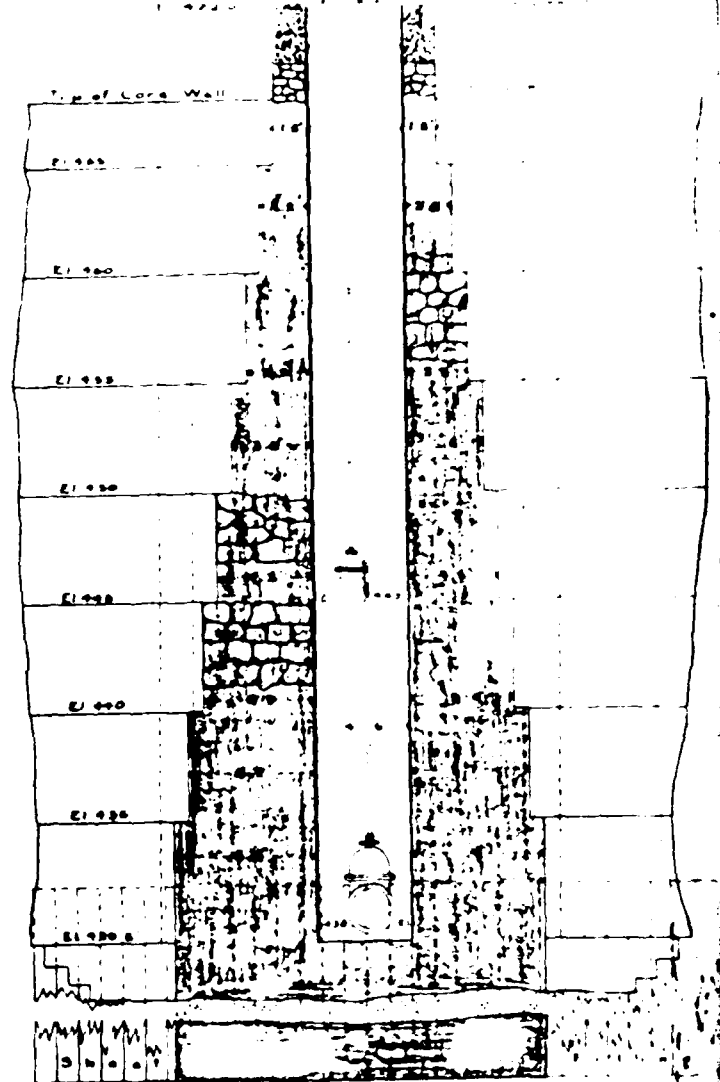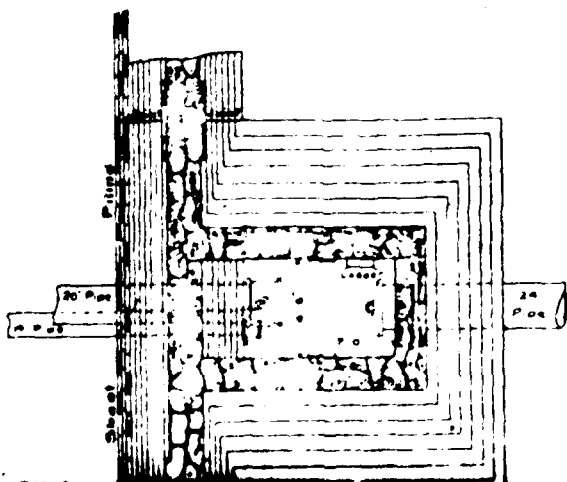
Section through center line of Wasteway

Section on line I

Section on line G H

Top of Embankment

Paving laid in Cement Mortar

Paving laid in Cement M

Top of Embankment

Plan of Wasteway

Section through center line of Wastewa

g laid in Cement Mortar

Embankment

asteway

Section on line X - Y

Section on line M-

Section on line O - P

line of Wasteway

PORTER BROOK RESERVO
Cheney Bros. South Mancheste
DRAWINGS OF DAM
DETAILS OF WASTEWAY

Scale : ⅛" 1'   July . 190

Freeman C. Coffin

Desmond File

Section on line X - Y

Section on line M-

Section on line O - P

Section on line K L

PORTER BROOK RESERVOIR
Cheney Bros. South Manchester, Conn.
DRAWINGS OF DAM
DETAILS OF WASTEWAY

Scale : ⅛ 1"   July . 1902.

Section on line K-L

Section on line X-Y

Concrete

Heavy Paving
laid dry

Section on line M-

Section on line O-P

PORTER BROOK RESERVOIR

Cheney Bros. South Manchester, Conn.
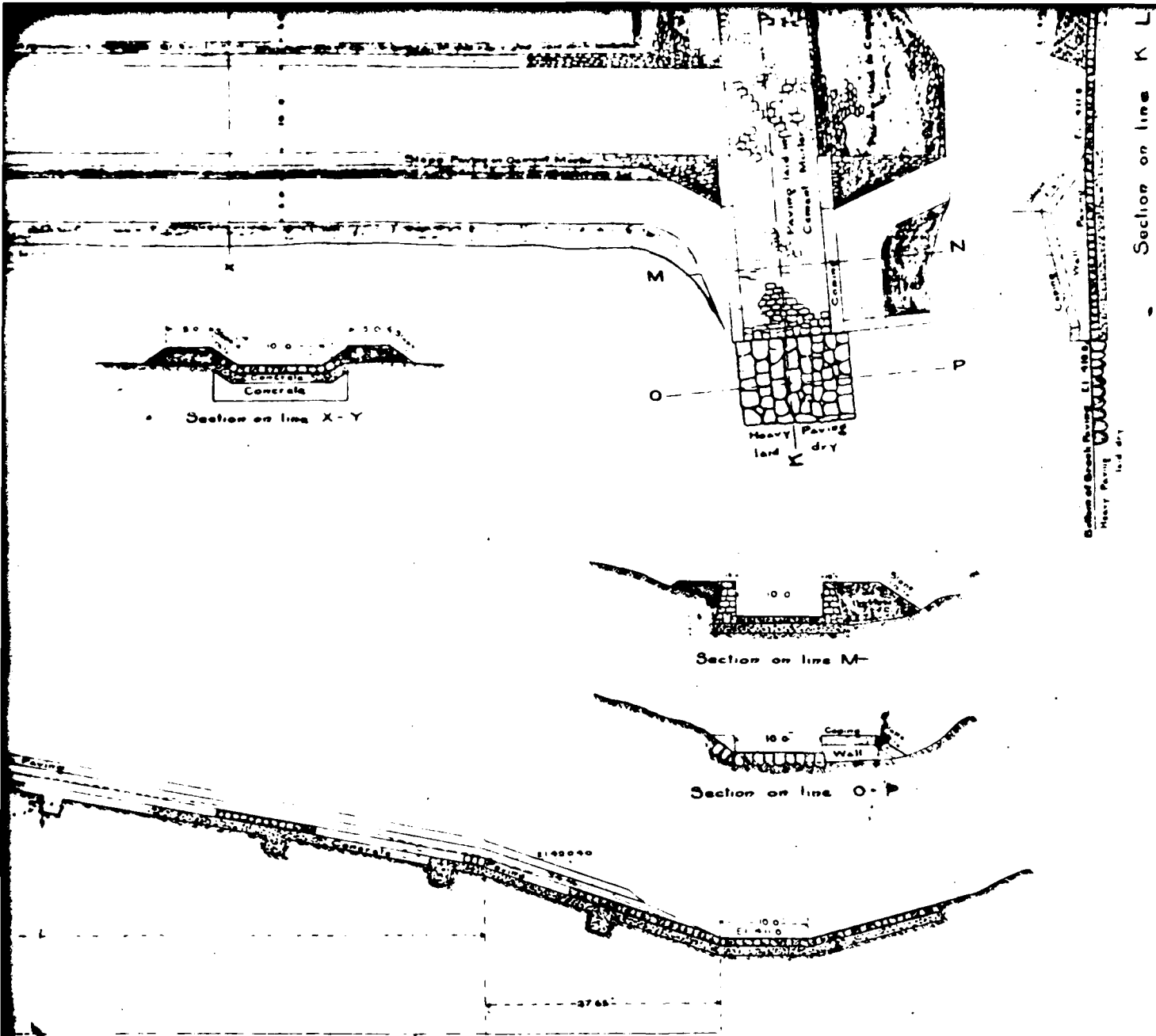
DRAWINGS OF DAM

DETAILS OF WASTEWAY

Scale : ⅛" 1'   July . 1902

Freeman C. Coffin
53 State St. Boston
Designing Engineer

Desmond Fitz Gerald
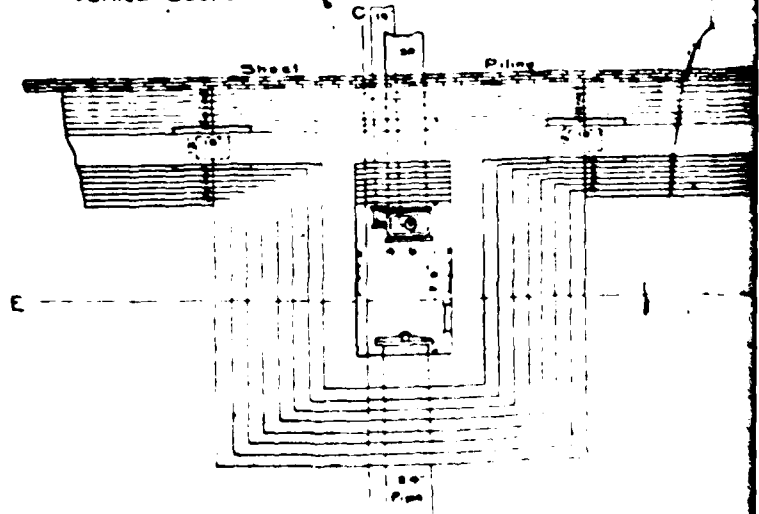Boston
Consulting Engineer

DRAWING NO. 34

GATE HOUSE

Scale ¼" = 1'

Top of Core Wall +???   A

B

Top of Core Wall

El +??

El +??

El +??

El +??

El +??

El +??

El +??

El +40

El +40

El +35

El +30

20 Pipe
El +30

El +30.0

Vertical Section through Gate House on line E - F

Masonry to Ledge

Vertical Section through
Gate House on line C - D

Sheet Piling

E

Plan of Gate House

Freeman C. Coffin
53 State St Boston
Designing Engineer

House on line E - F

Piling

F

WEIR CHAMBER

Section through chamber on line G - H

Plan of Weir Chamber

PORTER BROOK RESERVOIR

Cheney Bros. South Manchester, Conn.

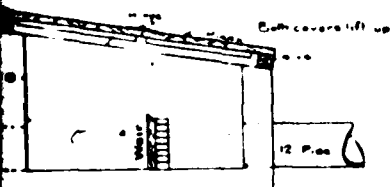## DRAWINGS OF DAM

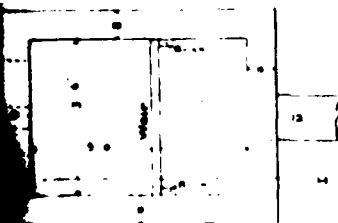### DETAILS OF GATE HOUSE

Scale see drawings   July. 1902

Freeman C. Coffin
53 State St Boston
Designing Engineer

Desmond FitzGerald
Boston
Consulting Engineer
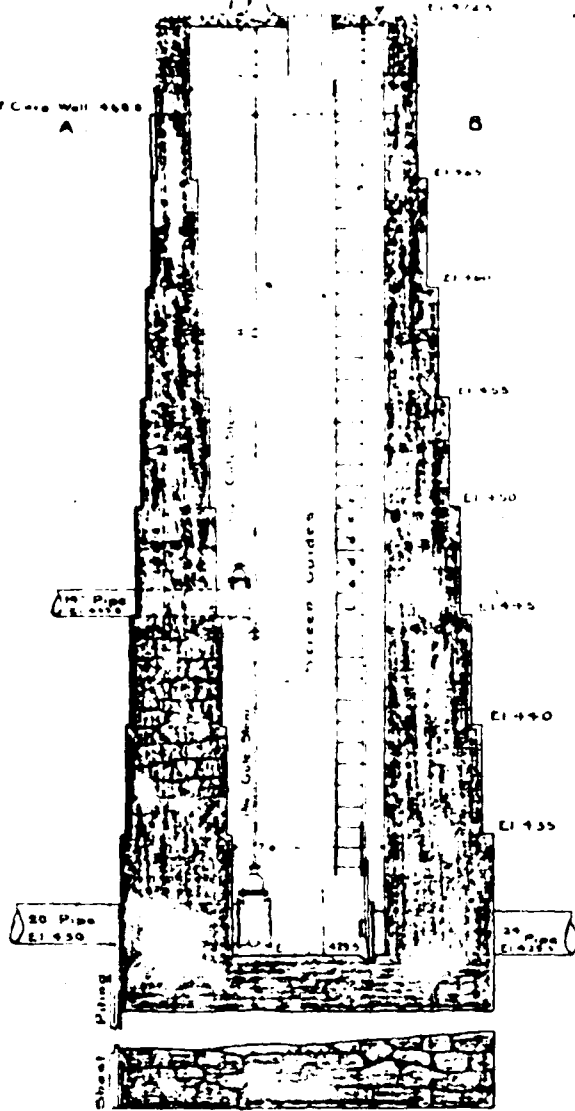
WEIR CHAMBER

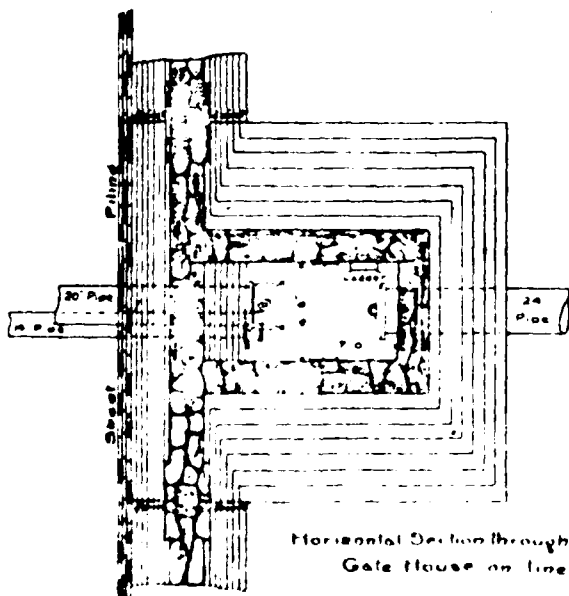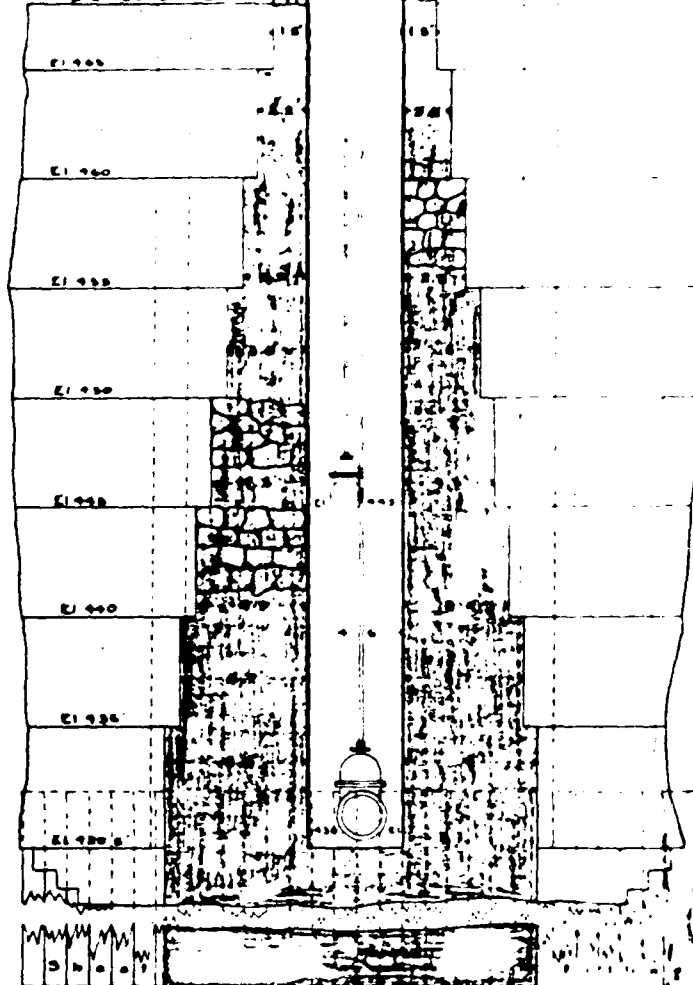Section through chamber on line G·H

Plan of Weir Chamber

Vertical Section through
Gate House on line C - D

Horizontal Section through
Gate House on line A - B

Vertical Section through Gate House on line E - F
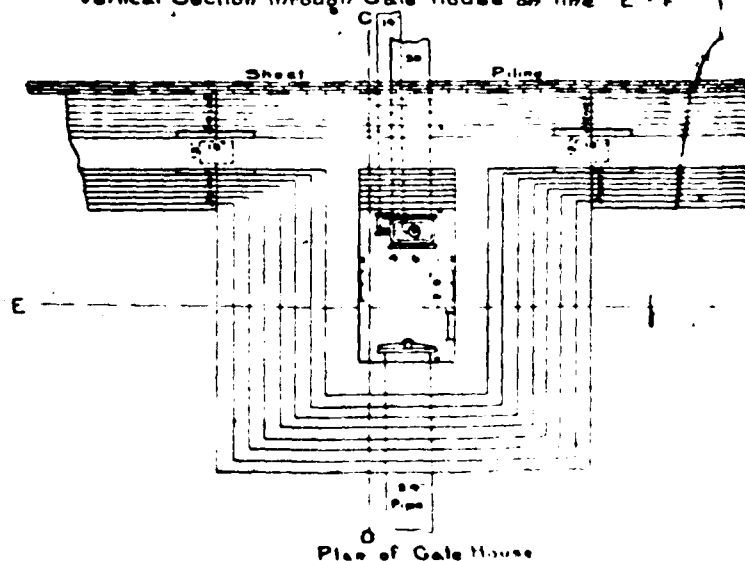
Plan of Gate House

PORTER BROOK

Cheney Bros. South

DRAWINGS O

DETAILS OF GAT

Scale see drawings

Freeman C. Coffin
53 State St Boston
Designing Engineer
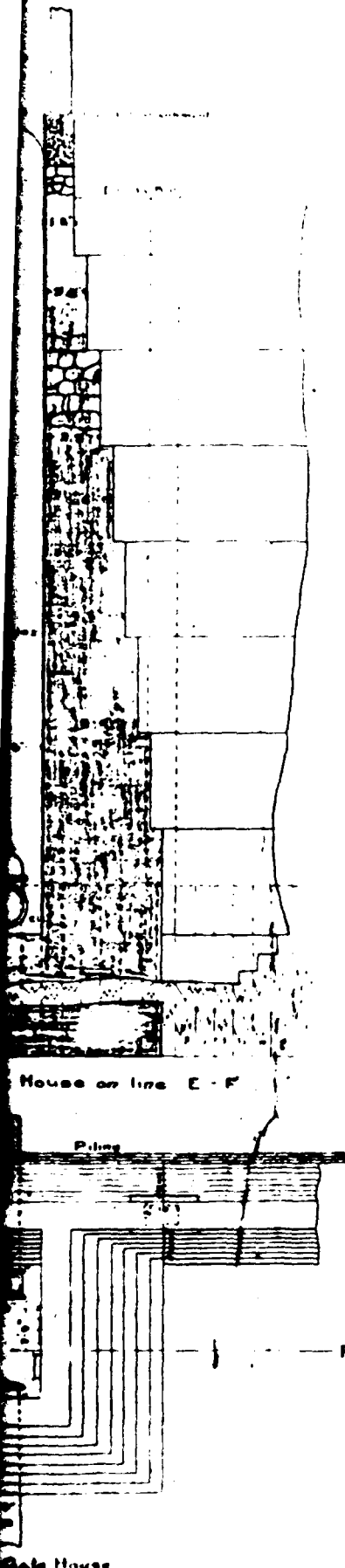
House on line E · F

Piling

House on line E · F

F

Gate House

WEIR CHAMBER

Both covers lift up

18" Pipe

Weir

12 Pipe

Section through chamber on line G · H

12

Weir

12

G

H

Plan of Weir Chamber

Scale

JOHN W. THOMPSON MAYOR
PASCAL A PRIGNANO ESQ   DEPUTY MAYOR
ANTHONY F PIETRANTONIO SECRETARY

DIRECTORS
JAMES F. FARR
MRS. VIVIAN F. FERGUSON
WILLIAM E. FITZGERALD ESQ
CHARLES H McKENZIE
JON L. NORRIS
JOHN J. TANI

Town of Manchester

Manchester. Conn. 06040

December 7, 1972

Mr. William H. O'Brien, III
Civil Engineer
Water and Related Resources
State of Connecticut Department of Environmental Protection
State Office Building
Hartford, Connecticut   06115

Re: Dam at Howard Reservoir
     Manchester, Conn.

Dear Mr. O'Brien:

I have asked Mr. Jay Giles, P. E., Administrator of the
Manchester Water & Sewer Department, to call you and
indicate the status of the hydrological report on the
above referenced watershed.

We will remove the flashboards until such time as the
study is complete.

Very truly yours,

William D. O'Neill,
Director of Public Works

WDO'N:s

cc: Mr. Jay J. Giles, Administrator, Water & Sewer Dept.

July 6, 1972

Mr. James Thompson
Buck and Buck Engineers
71 Capitol Avenue
Hartford, Connecticut

                              Re: Howard Reservoir Dam
                              Manchester

Dear Jim:

        Under the terms of your contract to act as a consultant to
this department, would you please inspect the subject dam and send
us a report on the safety thereof?

        Some seepage has been noted along the downstream toe. The
enclosed plans are the only ones we have. Please return them when
you are through with them.

                              Very truly yours,

                              William H. O'Brien, III
                              Civil Engineer

WHO:ljg

Enclosure

Town of Manchester

Manchester, Conn. 06040

BEF B. WEISS, GENERAL MANAGER

June 2, 1972

Mr. William H. O'Brien, III
Civil Engineer
Department of Environmental Protection
State of Connecticut
State Office Building
Hartford, Connecticut 06115

Dear Mr. O'Brien:

Per your request, I have had our old paper copies of Howard
Dam drawings photographed and new copies made. Enclosed is
one set of these drawings for your information and files.

You will note that Howard Reservoir was originally named
Porter Brook Reservoir and the spillway was not constructed
as shown on the original drawings.

If you have any questions please call me (649-5281, EXT. 251
or 252) at your convenience.

Very truly yours

Jay J. Giles
Administrator Water & Sewer Dept.

JJG:mb

cc: William D. O'Neill
     Superintendent Water
     and Sewer Dept.

June 1, 1972

Mr. William D. O'Neill
Water & Sewer Superintendent
Town of Manchester
Manchester, Connecticut 06040

Dear Mr. O'Neill:

Thank you for your letter of May 15, 1972.

In light of the fact that we are already into the hurricane
season in August and September, it would be advisable to have an
engineering analysis of the ability of the dam to safely pass the
runoff from large storms prior to this time, so that some temporary
corrective action could be taken if indicated. Final plans for the
provision of an adequate spillway could be submitted at a future
date, but the preliminary hydrology and hydraulics to define the
extent of the problem should be submitted as soon as possible. It
appears that Mr. Giles is ably qualified to submit such a report.

Thank you for your cooperation.

Very truly yours,

William H. O'Brion, III
Civil Engineer

WHO:ljg

JOHN W. THOMPSON MAYOR
PASCAL A PRIGNANO ESQ DEPUTY MAYOR
ANTHONY F PIETRANTONIO SECRETARY

DIRECTORS
WILLIAM J DIANA ESQ
JAMES F FARR
MRS VIVIAN F FERGUSON
WILLIAM E FITZGERALD ESQ
JON L NORRIS
JOHN J TANI

Town of Manchester

Manchester, Conn. 06040

IER J. WEISS, GENERAL MANAGER

May 15, 1972

William H. O'Brien, III, Civil Engineer
State of Connecticut Department of
Environmental Protection
State Office Building
Hartford, Conn. 06115

                    Re: Howard Reservoir Dam
                           Manchester

Dear Mr. O'Brien:

Mr. J. Giles has begun the study of runoff and spillway
capacity in accordance with your May 3, 1972 letter.
He is a graduate Civil Engineer registered in the State
of Pennsylvania.   He has performed similar studies as
a member of the consulting firm of Gannett Fleming
Corddry and Carpenter, Inc. of Harrisburg, Pennsylvania.

He will make every effort to accommodate the July schedule.
However, I would appreciate the time extension inasmuch as
this reservoir should not be full during the months of
August and September.

                    Very truly yours,

                    William D. O'Neill, P. E.
WDO'N:s   Water & Sewer Superintendent

cc: Robert B. Weiss, General Manager
       Jay J. Giles, Water & Sewer Administrator
       Walter J. Senkow, Town Engineer

May 3, 1972

Town of Manchester
Municipal Building
4 Center Street
Manchester, Conn. 06040

Attention: William D. O'Neill
            Director of Public Works

                              Re: Howard Reservoir Dam
                                  Manchester

Dear Mr. O'Neill:

        Thank you for your letter of April 25, 1972, regarding the subject dam.

        Your request to leave the spillway with just one board removed for an-
other two months during which time you expect the water level to be dropping,
appears to be a reasonable one.

        Our position is that the spillway is inadequate with all the boards in
place because to accommodate the design outflow, water would overtop the con-
crete wing walls and could erode the earth sideslopes which are undoubtedly
not designed for this. If you wish to leave all but one board in place until
the end of June it would be adviseable to place additional erosion protection
on these earth sideslopes. We do not understand why it should take six months
to make a study of the runoff and spillway capacity and request that it be
submitted by the end of July. The time table for the submission of plans and
the completion of the work indicated by the report would be reevaluated after
reviewing your engineer's report. The requirements of the department are that
plans submitted for approval be prepared by an engineer registered in the State
of Connecticut.

        Our minimum criteria for a dam of this size and location would be that
the spillway should be adequate to pass the runoff from precipitation equal to
1.5 times the one hundred year storm with adequate freeboard. We would suggest
that your engineer investigate the probable results from the maximum probable
rainfall and the engineering requirements to meet this design.

        Please advise if you will be able to meet these requests.

                              Very truly yours,

                              William H. O'Brien, III
                              Civil Engineer

WHO:ljg

cc: Robert B. Weiss, General Manager

Town of Manchester

Manchester. Conn. 06040

April 25, 1972

Mr. William H. O'Brien, III
Civil Engineer
Department of Environmental Protection
State of Connecticut
State Office Building
Hartford, Connecticut 06115

Dear Mr. O'Brien:

I have your letter of April 14, 1972 in which you describe your staff's inspection of our Howard Dam and the items you are requesting of us.

In a telephone conversation with me and later with Mr. Jay Giles, Water and Sewer Department Administrator, you voiced your concern about water flowing over the top of the spillway flashboards and above the top of the concrete wing walls. Following your conversation with Mr. Giles he had the top flashboard removed and the water level has dropped to about 6-inches below the top of the wing walls.
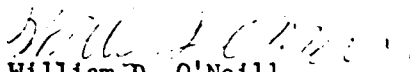
In your letter you ask that, by June 21, 1972, we submit a hydrologic study of the Howard Watershed, including the maximum expected runoff and the capacity of the spillway. We feel that we have the "in house" capability to prepare such a study but will find it very difficult, if not impossible, to submit it on the required date. Mr. Giles has had experience with such work, having completed such a study for the U.S. Navy at Quantico, Virginia only last year, and requests that we be given an extension to about October 31, 1972 to submit the report. In either case, what are your requirements with regard to the design flood (maximum probable, 100 yr., 50 yr., etc.)

If we remove all flashboards immediately, as you request, we will lose about 15 million gallons of water. If you would allow us to leave the boards on until about the end of June the water level should be down to the top of spillway at that time and we will not lose any water by removing them. These flashboards have been in place during the spring, summer and fall of each year for twenty or more years without any serious problems. On one occasion in the 1950's the water rose to an unacceptable level during heavy rains but the excess was released to the stream through the Reservoir's blowoff line.

If our study reveals that the spillway capacity with flashboards is inadequate we will definitely not install them in the future. If the study reveals that the spillway itself is inadequate we will have our consulting engineers prepare plans and specifications as you request.

We realize that Howard Dam, not unlike most dams in Connecticut, is a dam which might endanger life or property in the event of failure. We feel however, that Howard Dam is in excellent condition and the possibility of it failing is remote. With that in mind we feel that the timetable you have set for a report, plans, and construction, all within a period of six months, is extremely tight. If improvements are necessary, the preparation of plans, the allocation of funds, the Bidding of contracts, and the performance of work will most certainly take longer than the four months you have allocated for these tasks. We are more than willing to cooperate with the Department of Environmental Protection and trust that you will take this in consideration in this matter.

Very truly yours

William D. O'Neill
Director of Public Works

WDO'N:mb

STATE OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

STATE OFFICE BUILDING   HARTFORD, CONNECTICUT 06115

April 14, 1972

To n of Manchester
Municipal Building
41 Center Street
Ma chester, Conn.

Attention: Mr. Robert B. Weiss
General Manager

Re: Howard Reservoir Dam
Manchester

G tlemen:

According to the records in this office, the dam on Porter Brook in the Town of Manchester, known as Howard Dam is under your ownership.

Since this is a dam which might endanger life or property in the event of failure, it is under the jurisdiction of this department under Section 130 of Public Act No. 872, a copy of which is enclosed.

This dam was inspected by our staff on March 3, 1972, at which time it was r ted that boards had been placed in the spillway for the full spillway height of 3 feet and that the water level was approximately 18 inches below the top of the boards. On March 3, 1972 the dam was reinspected by our staff and the water had] sen to the top of the flashboards and was flowing over the top of the boards just above the top of the concrete wing walls of the spillway. It was also noted that above the top of the concrete wing walls there are unprotected earth side-slopes to the top of this earth dam. There is a definite hazard associated with the existing use of flashboards at this dam in that the earth side-slopes could become eroded leading to a failure of the dam.

It is also noted that there was seepage detected near the downstream toe of the earth embankment.
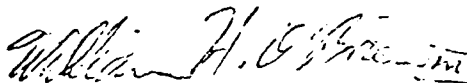
We request the following:

1. That you submit a report, prepared by an engineer registered in the State of Connecticut with an hydrologic study of the maximum runoff expected from the drainage area and an hydraulic analysis of the spillway capacity.

2. That if such report indicates an inadequate spillway capacity (considering two feet of freeboard) that engineering plans be submitted to provide adequate and safe outflow capacity for flood flows.

3. That all boards be immediately removed from the spillway until such report is submitted, at which time the replacement of some of the boards would be reevaluated, unless other evidence indicates that leaving them would not endanger the safety of the structure.

4. That an engineering report as specified in item #1 be submitted by June 21, 1972; that plans as specified in #2 by submitted by July 30, 1972, that indicated work be completed by October 30, 1972.

We request a reply within two weeks as to your intentions.

Very truly yours,

William H. O'Brien, III
Civil Engineer

IO:ljg

nclosure

INTERDEPARTMENT MAIL

DATE April 5, 1972

	DEPARTMENT
il	Water & Related Resources
ictor F. Galgowski, Supt. of Dam Maintenance	**DEPARTMENT** Water & Related Resources

Howard Reservoir Dam, Manchester 3 H6.8H7.1P1.9

Dam inspected by undersigned on March 1, 1972. A sizeable wet area at the toe of the dam was noted. This should be rechecked after the snow melts.

A number of trees growing on the dike north of the spillway should be removed.

Two inch flashboard planks to a height of 36 inches were bolted to the concrete abutments with angle iron brackets.
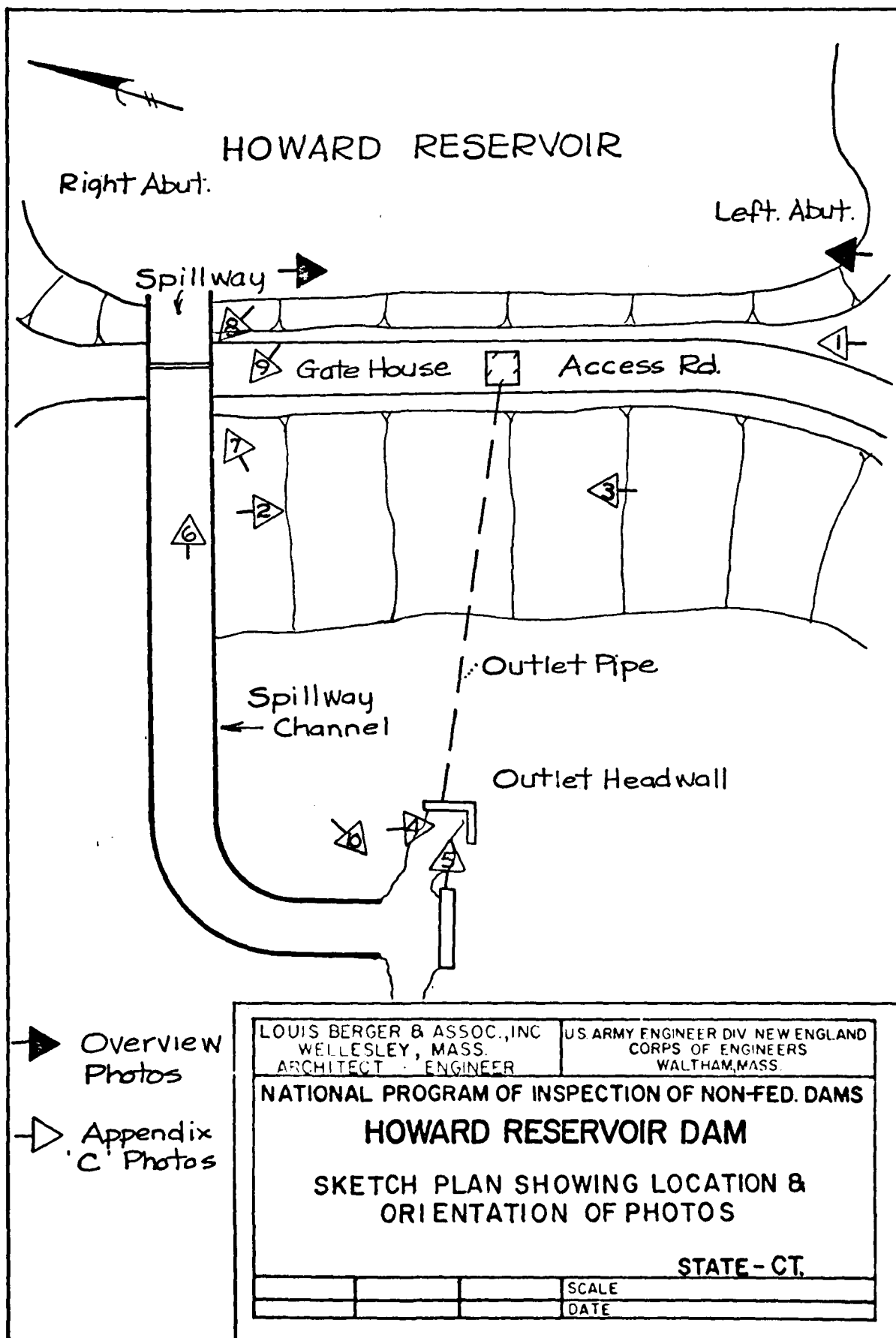
At the time of inspection the water level was 18 inches above the concrete spillway crest.

Victor F. Galgowski
Supt. of Dam Maintenance

VFG:ljg

APPENDIX C

PHOTOGRAPHS

HOWARD RESERVOIR

Right Abut.

Left. Abut.

Spillway

Gate House   Access Rd.

Outlet Pipe

Spillway
Channel

Outlet Headwall

Overview
Photos

Appendix
'C' Photos

LOUIS BERGER & ASSOC.,INC WELLESLEY, MASS. ARCHITECT · ENGINEER	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	

HOWARD RESERVOIR DAM

SKETCH PLAN SHOWING LOCATION & ORIENTATION OF PHOTOS

STATE - CT.

SCALE

DATE

1. Minor brush growth coming through riprap on upstream slope.

2. Well established brush growth on downstream slope.

3. Well established brush and tree growth at downstream toe of dam.

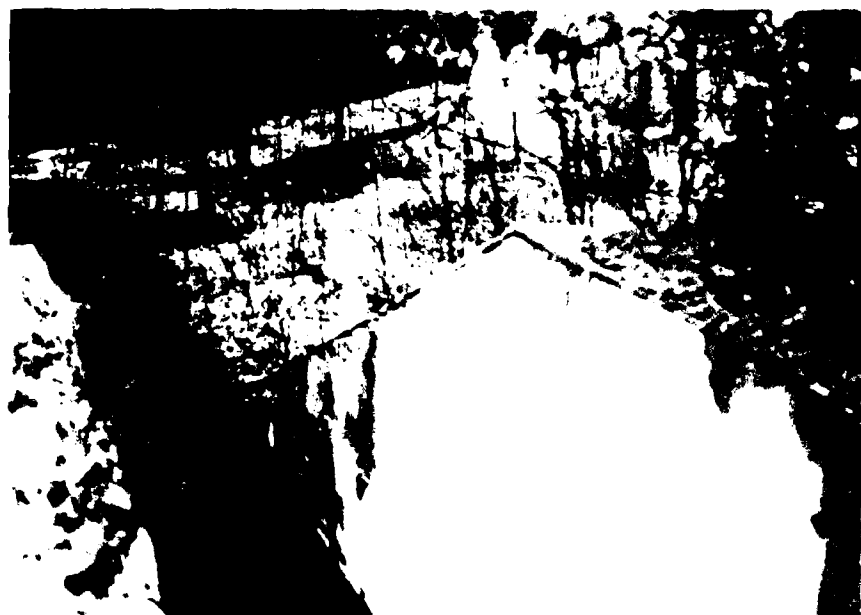4. Outlet pipe from toe drainage system.

5. Outlet pipes from gate house

6. View of spillway channel looking upstream.

7. Spillway crest.

8. Deteriorated cap of right spillway training wall.

9. Tree growth in downstream spillway channel.

10. Downstream spillway channel at confluence with Porter Brook.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

CAPACITY ANALYSIS

ELEV. MSL	AREA (AC)	AV. AREA (AC)	HT. (FT.)	INCR. STG. (AC-F)	CUM. STR. (AC-FT)	SURCHARGE STOR. (A-F)	REMARKS
454	0	0	0	0	0	0	24"∅ INVERT
460	5.2	2.6	4	10.4	10.4	0	
465	7.4	6.3	5	31.5	41.9	0	
470	9.2	8.3	5	41.5	83.4	0	
475	10.9	10.0	5	50.0	133.4	0	
480	12.8	11.8	5	59.0	192.4	0	
485	15.3	14.1	5	70.5	262.9	0	
489	17.9	16.6	4	66.4	329.3	0	SPILLWAY CREST
490	18.8	18.3	1	18.3	347.6	18.3	
491	19.7	19.2	1	19.2	366.8	37.5	
492	20.6	20.1	1	20.1	386.9	57.6	TOP SPILLWAY
493	21.6	21.1	1	21.1	408.0	78.7	
494	22.7	22.1	1	22.1	430.1	100.8	
495	23.9	23.3	1	23.3	453.4	124.1	
496	25.2	24.5	1	24.5	477.9	148.6	TOP DAM
497	26.6	25.9	1	25.9	503.8	174.5	
498	28.2	27.2	1	27.2	531.0	201.7	
499	30.0	29.1	1	29.1	560.1	230.3	
500	32.1	31.0	1	31.0	591.1	261.8	
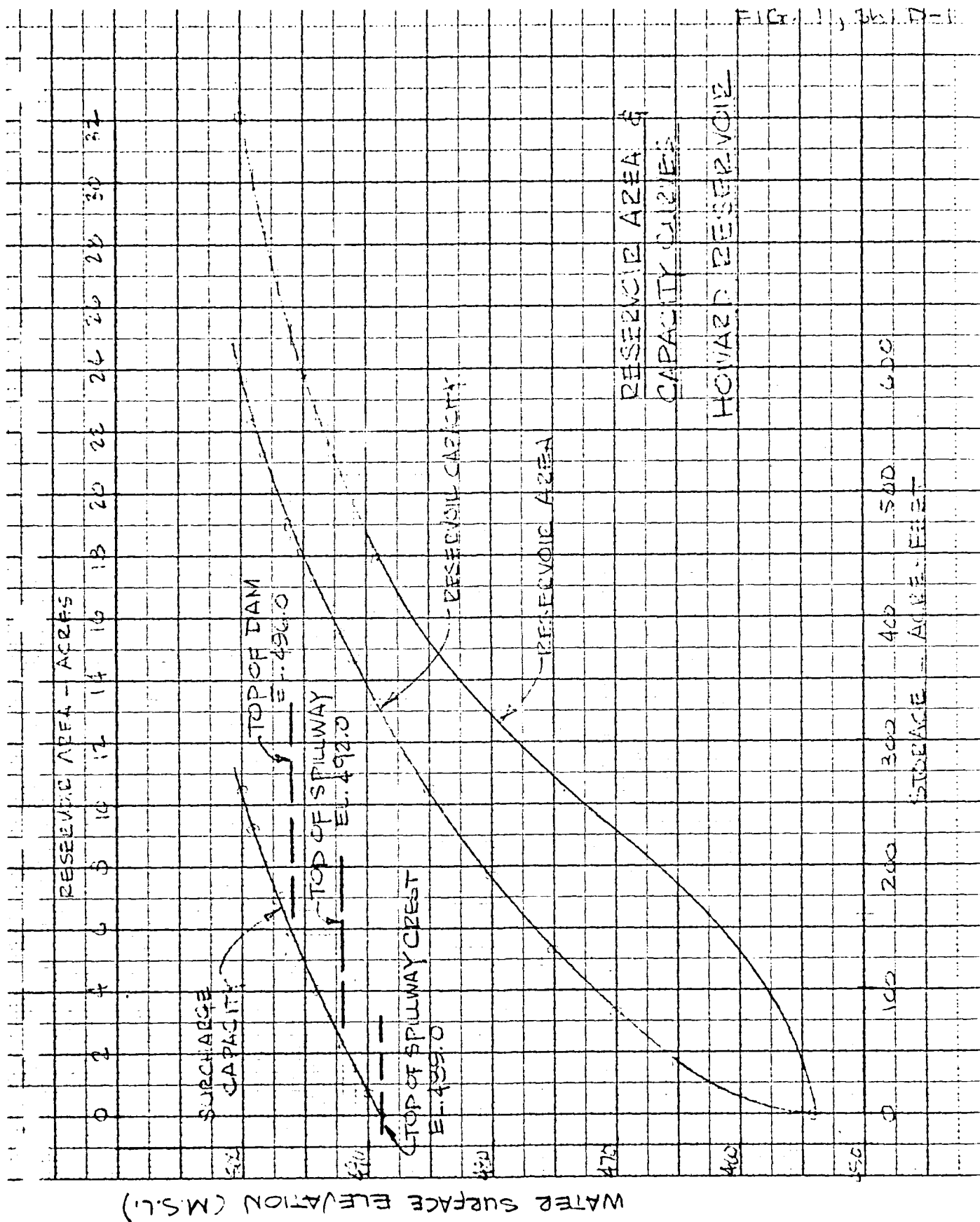
RESERVOIR AREA &
CAPACITY CURVES

HOWARD RESERVOIR

FIG. D-1

D-2

DRAINAGE AREA = 550.0 AC = 0.86 SQ. MI.

RESERVOIR AREA = $P.L. = \dfrac{0.195 \times 4,120,620}{43,560}$ = $\dfrac{17.91 \, AC}{640}$ = 0.028 SQ MI.

= 3.2% OF DA

CAPACITY AT NORMAL STORAGE = 120 MILLION GALLONS
(CITY OF MANCHESTER)

SPILLWAY CREST ELEV. = 489 MSL

RESERVOIR LENGTH = 1400' ±

WIDTH = 900' ±

DRAINAGE AREA
TRIBUTARIES TO DRAINAGE AREA

L	H	S
1. 7,300	725 - 489 = 236	236 ÷ 7,300 = 0.0323
2. 7,200	616 - 489 = 127	127 ÷ 7,200 = 0.0176
3. 8,300	755 - 489 = 266	266 ÷ 8,300 = 0.0321
3) 22,800		3) 0.0820

L_{AV} = 7,600' = 1.44 MI.

S_{AV} = 0.0273 '/ = 1443 FT/MI.

LAG TIME FOR UNIT HYDROGRAPH

$LAG = K \left(\dfrac{L \, L_{CA}}{\sqrt{S}} \right)^{0.33}$

$L_{CA} = \frac{1}{2} = \frac{1.44}{2} = 0.72 \, M$

$S = 1443 \, FT/MI.$

$K = 3.75$ CURVE "B" MIXED

$= 3.75 \left(\dfrac{1.44 (0.72)}{\sqrt{1443}} \right)^{0.33}$

$= 3.75 \, (0.0863)^{0.33}$ = 1.67 HRS   SAY 1.7 HRS

CHECK VELOCITY

$V = \dfrac{7600}{(3600)(1.7)}$ = 1.24 FPS   OK ✓

CALC T_P (TIME TO PEAK)

$$T_P = \frac{LAG}{1.22} + \frac{D}{2(1.22)}$$

$D = 1.0$ (SET)
PG 69 DSD
(MODIFIED)

$$= 0.82\, LAG + 0.42\, D$$
$$= 0.82(1.7) + 0.42(1.0)$$
$$=$$
$$T_P = 1.39 + 0.42 = 1.81 \qquad \text{USE } 1.8 \text{ HRS}$$

UNIT HYDROGRAPH
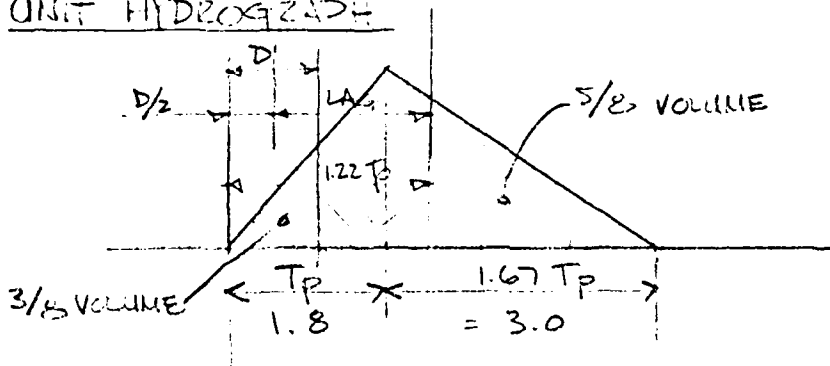
Q_P Q TO PEAK

$$Q_P = \frac{484\, A Q}{T_P}$$

$A = 0.86$ SQ. MI.   PG. 69 - DSD
$Q = 1.0''$
$T_P = 1.8$ HRS

$$= \frac{484(0.86)(1)}{1.8}$$

$$= \underline{231.2 \text{ CFS}}$$

RAINFALL   24" RAINFALL IN 6 HRS   SET

$$PMF = 0.8(24) = 19.2$$

FIT FACTOR = 0.8
INFILTRATION = 0.4

$$19.2 - 0.4 = \underline{18.8 \text{ IN}}$$

FLOOD INFLOW HYDROGRAPH FOR PMF

$$Q_{P(1")} = 231 \text{ CFS}$$

TIME HZ	RAINFALL %*	RAINFALL IN	QP CFS	BEGIN HZ	PEAK HZ	END HZ
0						
1	10	1.88	434	0.0	1.8	4.8
2	12	2.26	522	1.0	2.8	5.8
3	15	2.82	651	2.0	3.8	6.8
4	38	7.14	1649	3.0	4.8	7.8
5	14	2.63	608	4.0	5.8	8.8
6	11	2.07	478	5.0	6.8	9.8
	100	18.8	4342.8			

* DIST. OF MAX. 6 HRS SPS OF PMP IN %

EM 1110-2-1411

(ACOE)

D-5

HOWARD RESERVOIR
INFLOW FLOOD HYDROGRAPH
FULL P.M.F.

INCREMENTAL HYDROGRAPHS
FOR OVERLAND RUNOFF
INCL. RESERVOIR

INFLOW (C.F.S.)

7,000
6,000
5,000
4,000
3,000
2000
1,000

TIME (HRS)
2   3   4   5   6

FIG 2. Sh. D-6

OIR
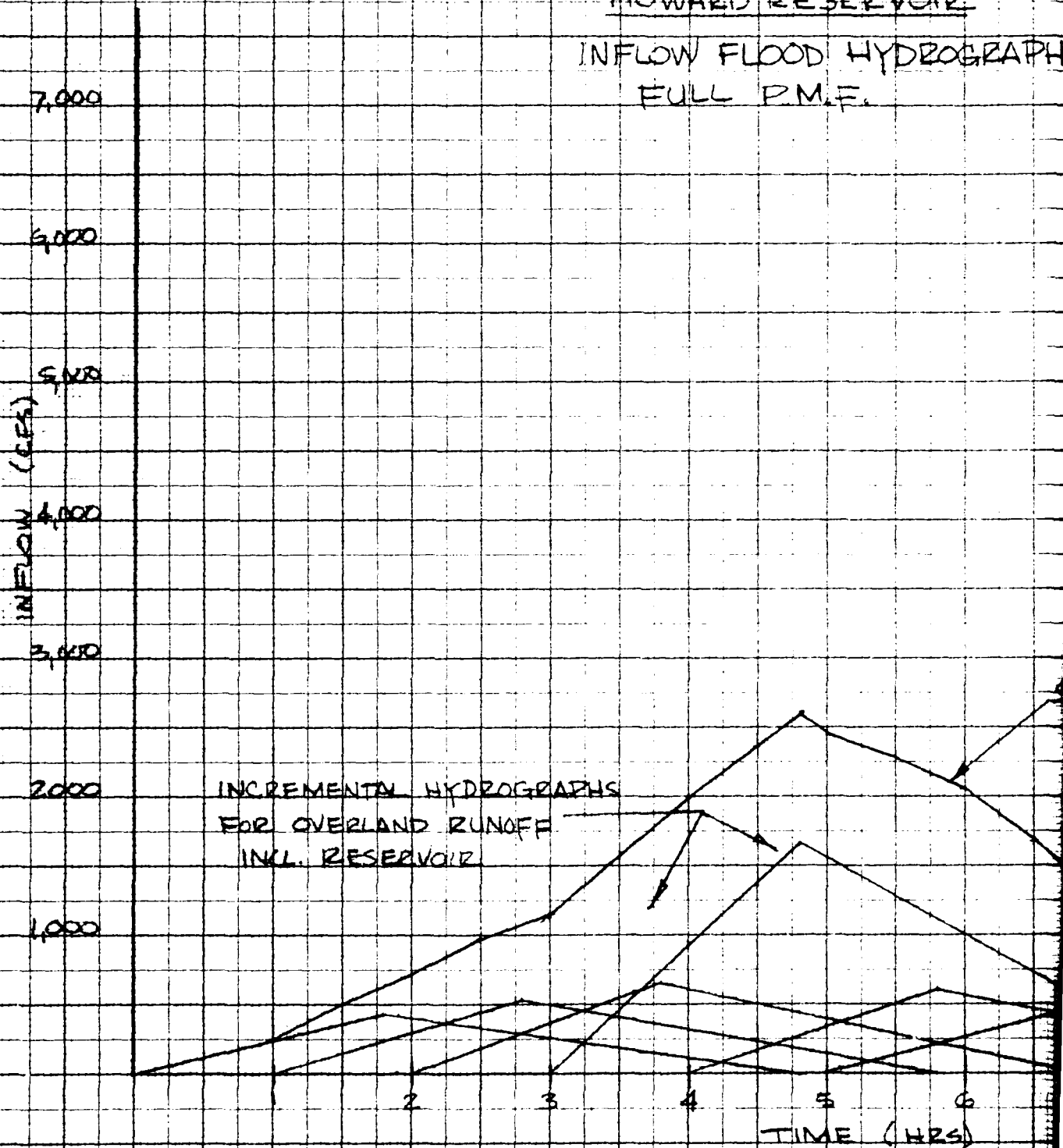
DROGRAPH

COMBINED INFLOW HYDROGRAPH
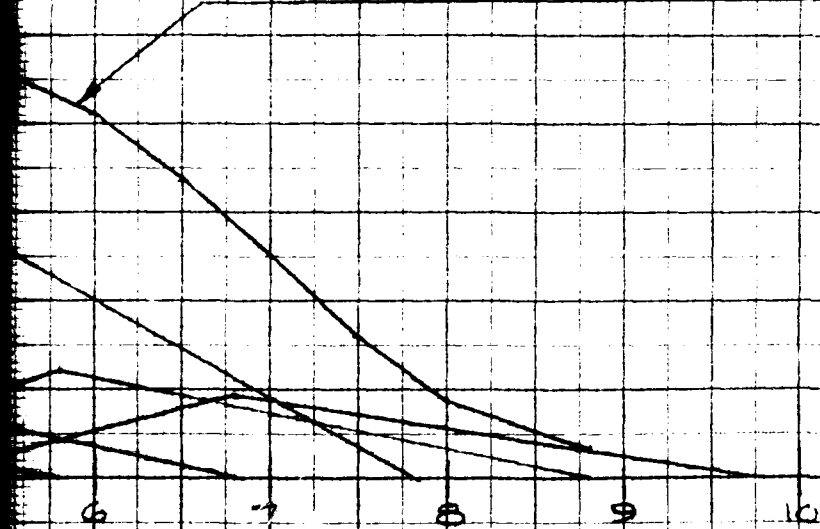
6   7   8   9   10

CFS)

D-6

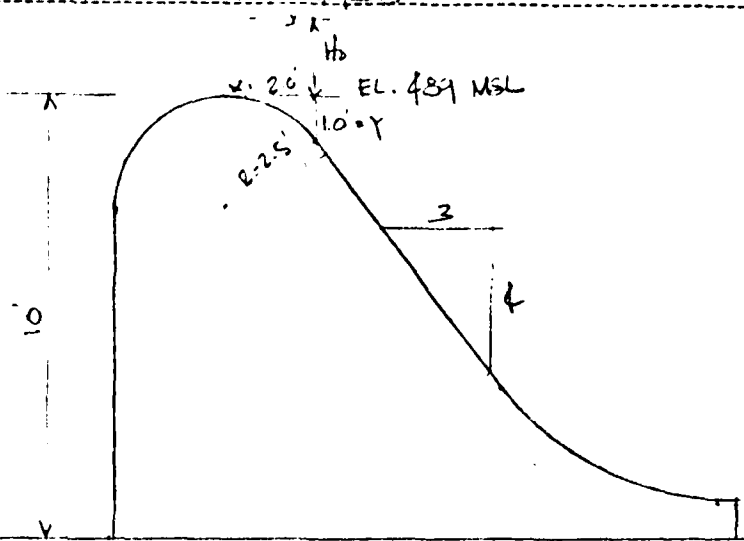ASSUME: $H_0 = 3'$, $C = \pm 4$

GIVEN: $P = 10'$
$\quad X = 2.0'$ $P + H_0 = 13$
$\quad Y = 1.0'$

$q = CH^{3/2} = 4(3)^{3/2} = 20.8 \, CFS/FT$

APPROACH $v = \dfrac{20.8}{13} = 1.6 \, FPS$

$h_a = \dfrac{v^2}{2g} = \dfrac{(1.6)^2}{64.4} = 0.04$

$\dfrac{h_a}{H_0} = \dfrac{0.04}{3} = 0.013$

FROM FIG. 247 DSD. $n = 1.865$ $k = 0.50$ $X = 2.0$
(VERTICAL UPSTREAM FACE) $\qquad Y = 1.0$

$\dfrac{Y}{H_0} = k\left(\dfrac{X}{H_0}\right)^n$

$\dfrac{1.0}{H_0} = 0.5\left(\dfrac{2.0}{H_0}\right)^{1.865}$

$\dfrac{1.0}{0.5} = H_0\left(\dfrac{2}{H_0}\right)^{1.865} = 2.0$

$\dfrac{(2.0)^{1.865}}{H_0^{0.865}} = 2.0$

$H_0^{0.865} = \dfrac{3.64}{2} = 1.82$

$\underline{H_0 = 2.0}$

$\therefore$ DESIGN HEAD $(H_0) = 2.0'$
$\qquad = 489 + 2.0 = EL\ 491\ MSL$

$\dfrac{P}{H_0} = \dfrac{10}{2} = 5.0$ FIG 249 $\dfrac{C_0 = 3.88}{\boxed{D \cdot 71}}$
$\qquad\qquad\qquad$ DSD

FOR $H_0 = 2.0$
$q = CH^{3/2} = 4(2)^{3/2} = 11.3$
$v = \dfrac{11.3}{12.\_\_} = 0.94 \, FPS$
$h_a = \dfrac{v^2}{2g} = 0.014$
$\dfrac{h_a}{H_0} = \dfrac{0.014}{2} = 0.007$
$n = 1.87$ $k = 0.50$

$\dfrac{1.0}{H_0} = 0.5\left(\dfrac{2.0}{H_0}\right)^{1.87}$

$2.0 = H_0\left(\dfrac{2.0}{H_0}\right)^{1.87}$

$2.0 = \dfrac{3.65}{H_0^{0.87}}$

$H_0^{0.87} = 1.82$ $\underline{H_0 = 2.0}$

$$Q_{1\&3} = CLH^{3/2} \quad \boxed{} \qquad \underset{②}{Q_2} = 2.5 \ TAN \frac{\theta}{2} H^{5/2}$$

$$① \qquad\qquad ② \qquad ③ \qquad \theta = 136° \quad Q = 6.2 H^{5/2}$$

ELEV	H_e ①	$\frac{H_e}{H_o}$	$\frac{c}{c_o}$	C	ΔQ ① CFS	H_e ②	ΔQ ②	H_e ③	ΔQ ③	ΔQ ④	$\Sigma \Delta Q$ CFS
489	0	0						L=702			0
489.5	0.5	0.25	.86	3.34	12						12
490	1.0	0.5	.92	3.57	36						36
490.5	1.5	0.75	.96	3.72	68						68
491	2.0	1.0	1.00	3.88	110						110
491.5	2.5	1.25	1.03	4.00	158						158
492	3.0	1.5	1.06	4.11	214	0	0				214
492.5	3.5	1.75	1.07	4.15	272	0.5	1				273
493	4.0			"	332	1.0	6				338
493.5	4.5			"	396	1.5	11				407
494	5.0			"	464	2.0	18				482
494.5	5.5			"	535	2.5	61				596
495	6.0			"	610	3.0	97				707
495.5	6.5			"	688	3.5	142				830
496	7.0			"	769	4.0	198	0	0	0	967
496.5	7.5		2.8	(4.15)	(887)	(4.7)	(296)	0.5	695	150	1812	OVER DAM 555
497	8.0			"	"	"	"	1.0	1966	285	3,218	225?
497.5	8.5			"	"	"	"	1.5	3611	592	5170	422?
498	9.0			"	"	"	"	2.0	5,560	975	7502	65??
498.5	9.5			"	"	"	"	2.5	7770	1425	10,162	9?5
499	10.0			"	"	"	"	3.0	10,214	1920	13,101	1,??
499.5	10.5			"	"	"	"	3.5	12,871	2460	16,292	15??
500.0	11.0			"	"	"	"	4.0	15,725	3052	19,744	1?,??
500.5	11.5			"	"	"	"	4.5	18,763	3682	23,412	22,??
501.0	12.0			"	"	"	"	5.0	21,976	4350	27,293	26,??
501.5	12.5			"	"	"	"	5.5	25,354	5055	31,376	30,??
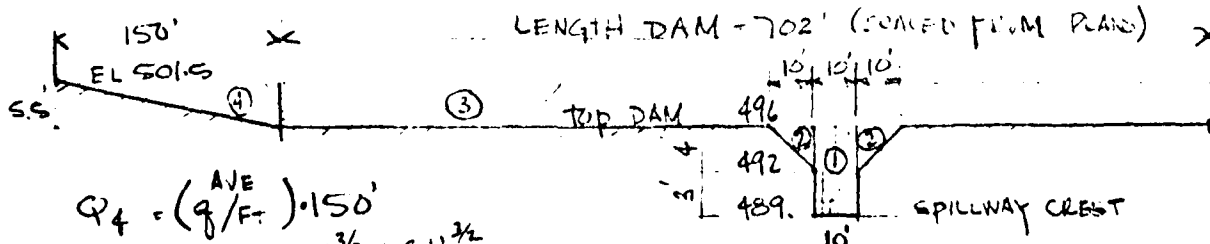
496.7
Q = 1182 cfs

LENGTH DAM - 702' (SCALED FROM PLAN)

EL 501.5   150'   ④   ③   TOP DAM   496   10' 10' 10'

S.S.   492 ② ① ②

    489.   SPILLWAY CREST   10'

$$Q_4 = \left(\overset{AVE}{q/F_t}\right) \cdot 150'$$

$$\overset{AVE}{q_{1-72}} = \frac{C_1 H_1^{3/2} + C_2 H_2^{3/2}}{2}$$

D-8

DISCHARGE CURVE
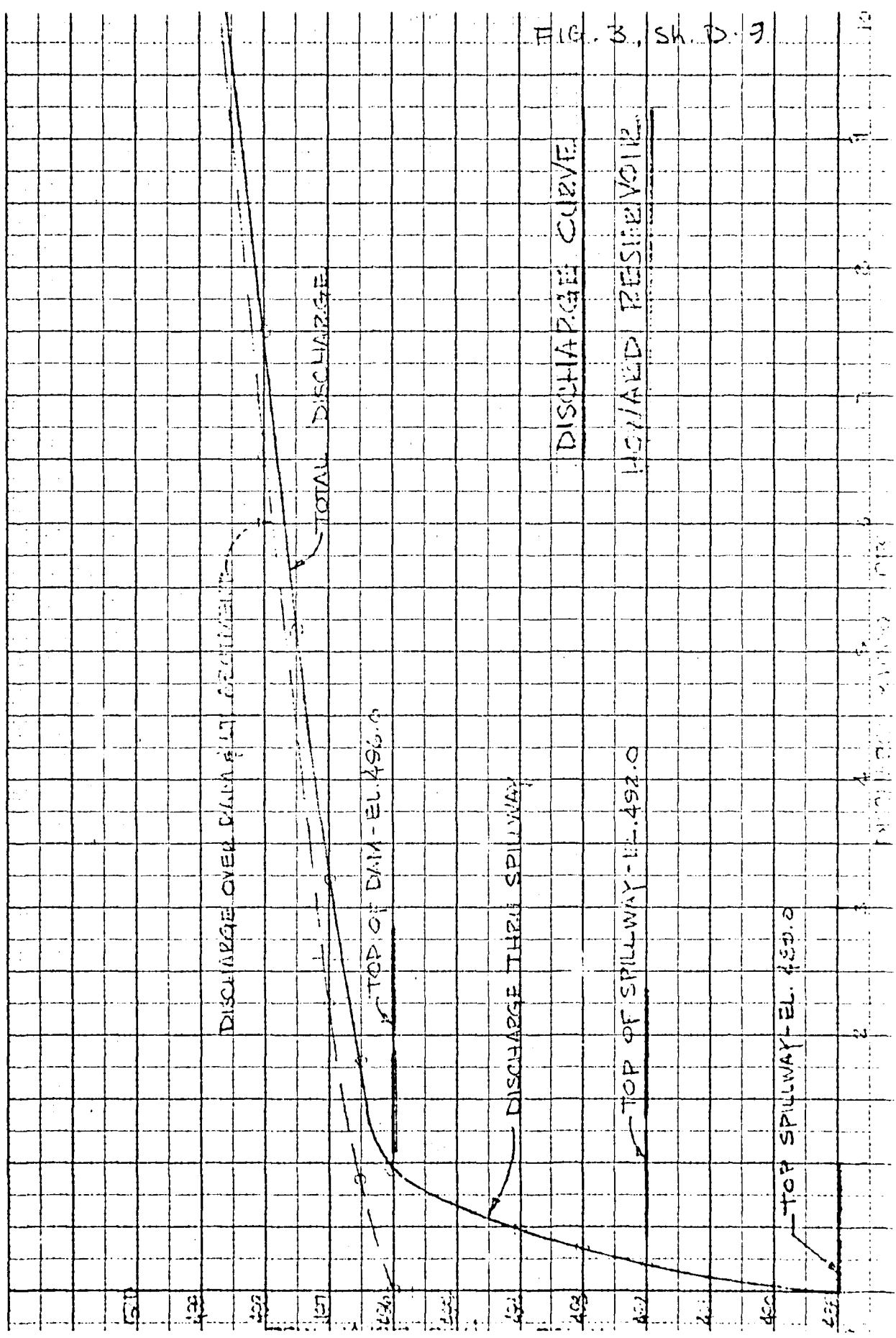
HOWARD RESERVOIR

FIG. 3, SH. D. 7

A_D = 0.86 SQ. MI.   HT. = 50'±   STORAGE = 120 M Gal

SIZE CLASSIFICATION = INTERMEDIATE   = 367 AC-FT (FROM CITY)

HAZARD CLASS - HIGH

550 AC.

INSPECTION FLOOD - ½ PMF TO PMF

PMF (FROM INFLOW HYDROGRAPH) = 2,600 CFS

STEP 1. Q_{P_1} = 2600 CFS

STEP 2:   a. SURCHARGE HEIGHT = 496.8 (FROM DISCHARGE CURVE)

    b. VOLUME OF SURCHARGE ($STOR_1$) IN INCHES

168 AC-FT (SURCHARGE AT EL. 496.8) FROM CAPACITY CURVE

$$STOR_1 = \left[\left(168 \times 43,560 \frac{cu.ft}{Ac.ft}\right) \div \left(550 \times 43,560\right)\right] \times 12$$

$$STOR_1 = 3.66 \ IN.$$

    c. $Q_{P_2} = Q_{P_1} \times \left(1 - \frac{STOR_1}{19}\right)$

$$= 2600 \times \left(1 - \frac{3.66}{19}\right) = 2600(1 - 0.19)$$

$$Q_{P_2} = 2106 \ CFS$$

STEP 3:

    a. SURCHARGE HT (Q_{P_2}) = 496.6

      VOLUME OF SURCHARGE ($STOR_2$) IN INCHES

    160 AC-FT (SURCHARGE AT EL. 496.6)

$$STOR_2 = \left[(160 \times 43,560) \div (550 \times 43,560)\right] \times 12 = 3.49 \ IN$$

D-10

STEP 2b:

$$STOR_1 = 3.66 \text{ IN}$$
$$STOR_2 = 3.49 \text{ IN}$$

AVERAGE STOR = 3.58 IN

$$\frac{3.58 \text{ IN} \times 550 \text{ AC}}{12} = \underline{164 \text{ AC-FT}}$$

AVE. STOR EL. FOR 164 AC-FT = 496.7 MSL

$$\underline{Q_{P_3} = 2300 \text{ CFS}} \quad (\text{FROM DISCHARGE CURVE})$$

∴ 496.7 = 0.7 FT ABOVE DAM & 7.7 FT ABOVE SPILLWAY.

SPILLWAY INADEQUATE TO HANDLE PMF OVERTOPPING

CHECK ½ PMF = 2600 ÷ 2 = 1300 CFS = Q_{P_1}

STEP 2a: SURCHARGE HT. = 496.38
   2b: " VOLUME = 155 AC-FT

$$STOR_1 = \frac{155 \text{ AC-FT}}{550} \times 12"/_{FT} = \underline{3.38 \text{ IN}}$$

2c: $Q_{P_2} = Q_{P_1} \times \left(1 - \frac{STOR_1}{9.5}\right)$

$$= 1300 \times \left(1 - \frac{3.38}{9.5}\right) = 1300(.644) = \underline{837 \text{ CFS}}$$

3a: SURCHARGE HT (Q_{P_2}) = 495.7
   " VOLUME = 140 AC-FT

$$STOR_2 = \frac{140 \text{ AC-FT}}{550} \times 12"/_{FT} = \underline{3.05 \text{ IN}}$$

D-11

STEP 3b:

$$STOR_1 = 3.38 \text{ IN}$$

$$\underline{3.05 \text{ IN}}$$

$$3.22 \text{ IN} = AV. \ STOR_{1\&2}$$

$$\frac{3.22 \text{ IN} \times 550 \text{ AC}}{12} = \underline{147.6 \text{ AC-FT}}$$

AVE STOR EL. FOR 147.6 AC-FT = 496.0

$$\underline{Q_{P3} = 950 \text{ CFS}}$$

$\therefore$ SPILLWAY JUST ADEQUATE TO HANDLE ½ PMF

<u>STEP 1:</u> RESERVOIR STORAGE AT FAILURE -
  ASSUME WATER ELEV. AT TOP OF DAM - 496.0

FROM CAPACITY CURVE : STORAGE AT EL 496.0 = <u>478 AC-FT</u>

<u>STEP 2:</u> PEAK FAILURE OUTFLOW

$$Q_{P_1} = 8/27 \; W_b \sqrt{g} \; Y_o^{3/2}$$

W_b = BREACH WIDTH = 40% DAM WIDTH AT MID HT.
  = 0.4 (260') = 104'   SAY <u>105 FT</u>

Y_o = TOTAL HT. FROM RIVER BED TO POOL LEVEL
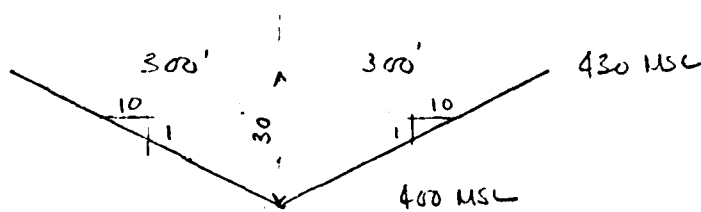 AT FAILURE
  = 47 FT (±) SCALED FROM PLAN A CTR CORE

$$Q_{P_1} = 8/27 \; (105') \sqrt{g} \; (47)^{1.5}$$

$$= (31.11)(5.67)(322.2) = 56,884 \; CFS$$

SAY $\boxed{Q_{P_1} = 56,900 \; CFS}$

STEP 3: <u>STAGE - DISCHARGE RATING FOR RIVER REACH</u>
                                    (Q vs. H)

<u>TYPICAL SECTION DOWNSTREAM</u>

300'   300'   430 MSL
 10   10
  1   1
   30

400 MSL

D-13

USING MANNING FORMULA - CALC. PTS. FOR STAGE-DISCHARGE CURVE

$$Q = VA = A\left(\frac{1.49}{n} R^{2/3} S^{1/2}\right)$$
$$\underset{V}{}$$

$S_{AV.} = \dfrac{80'}{2100'} = 0.038$ $n - 0.14$ -   HDS No. 3 pg 100.

$R = \dfrac{A}{P}$

H	AREA	P (WETTED PER.)	$R^{2/3}$	$S^{1/2}$	$1.49/n$	Q CFS
5'	250 SQ FT	100.5	1.84	0.195	10.64	954
10'	1000	201.0	2.92	"	"	6,049.
15'	2250	301.5	3.82	"	"	17,839.
20'	4000	402.0	4.63	"	"	38,425
24'	5760	482.4	5.23	"	"	62,484
25	6250	502.5	5.37	"	"	69,670
30'	9000	603.0	6.07	"	"	113,299

STEP #4: ESTIMATE Q_{P_2} — REACH OUTFLOW $S = 477$ AC-FT

$\frac{S}{2} = 239$ AC-FT

4A: FOR $Q_{P_1} = 56,900'$ — HT STAGE = 23.2'

ASSUME $L_{REACH} = 4,400'$ $A = 23.2 \times (23.2 \times 10) = 5,382$ SF
TO ROAD CROSSING (V_1) VOL$_{REACH} = (5,382) \times 4,400' =$

$= 23,682,560$ CF

$V_1 = 543$ AC-FT

$543 > \frac{1}{2}(478)$

∴ $V_1 > \frac{1}{2} S$ USE SHORTER REACH

TRY $L_{REACH_1} = 1500'$:

$V_1 = \dfrac{1500' \times 5382}{43,560} = 185$ AC $< 239 (= \frac{S}{2})$ OK.

4B: $Q_{P_2} = Q_{P_1} \left(1 - \dfrac{V_1}{S}\right)$

(TRIAL) $= 56,900 \left(1 - \dfrac{185}{478}\right) = 34,878$ CFS

4C: STAGE$_2$ = 19.2' $V_2 = \dfrac{(19.2 \times (19.2 \times 10)) \times 1500'}{43560}$
(TRIAL)   (TRIAL)

$= 126.9$ AC FT.

4D: $\dfrac{V_1 + V_2}{2} = V_{AV.} = \dfrac{185 + 126.9}{2} = 156$ AC-FT

∴ $Q_{P_2} = Q_{P_1} \left(1 - \dfrac{V_{AV}}{S}\right) =$

$= 56,900 \left(1 - \dfrac{156}{478}\right) = 38,060$ CFS

STAGE$_2$ = 19.9 FT   D-15

$\therefore$ AT 1500' DOWNSTREAM — Q_2 = 38,060 CFS

STAGE$_2$ = 19.2 FT

TRY L_{REACH_2} = 1500'

$$V_2 = \frac{1500' \times \overbrace{19.2 \times 142}^{A}}{43,560} = 126.9 \text{ AC-FT} < \frac{S}{2} \quad \text{OK.}$$

$$Q_{P_3} (TRIAL) = Q_{P_2} \left(1 - \frac{V_2}{S}\right)$$

$$= 38,060 \left(1 - \frac{127}{478}\right) = 27,942 \text{ CFS}$$

STAGE$_3$ (TRIAL) = 17.7 FT

$$V_3 = \frac{(17.7 \times 177) \times 1500'}{43,560} = 107.9 \text{ AC-FT}$$

$$\frac{V_2 + V_3}{2} = \frac{126.9 + 107.9}{2} \quad 117.4 \text{ AC-FT}$$

$$Q_{P_3} = Q_{P_2} \left(1 - \frac{V_{AV}}{S}\right) = 38,060 \left(1 - \frac{117.4}{478}\right)$$

$$= 28,712 \text{ CFS}$$

STAGE$_3$ = 17.9 FT

$\therefore$ AT 3000' DOWNSTREAM Q_{P_3} = 28,712 CFS

STAGE$_3$ = 17.9 FT

D-16

TYPICAL SECTION CHANGES AFTER 3000' DOWNSTREAM

H	AREA	P	R²/₃	S½	1.49/n	Q cfs	
5	600	250.2	1.79	0.195	10.64	2230	
10	2400	480.4	2.92	"	"	14,560	
15	5400	720.6	3.83	"	"	42,932	
20	960	960.8	4.64			92,469	
7	1176	336.3	2.30	"		5624	
13	4056	625	3.48			29,311	

NOTE — SECOND CURVE ADDED TO STAGE-DISCHARGE CURVE

AT 3000' DOWN STREAM — AREA OPENS UP — STAGE DROPS QUICKLY.

∴ AT 3000⁺' — Q_{P_3} = 28,712 CFS
DOWNSTREAM

$STAGE_3$ = 12.9 FT
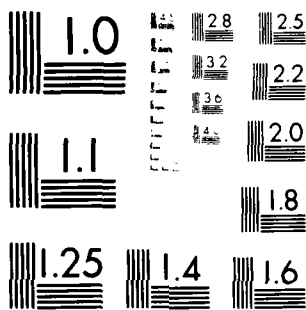
MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

TRY $L_{REACH_3} = 1400'$ (TO ROADWAY CROSSING)

$$V_3 = 1400' \times \frac{\overbrace{12.9 \times (12.9 \times 24)}^{A}}{43,560} = 128.4 < \frac{S}{2}$$

$$Q_{P4} \text{ (TRIAL)} = Q_{P3}\left(1 - \frac{V_3}{S}\right) = 28,712\left(1 - \frac{128.4}{478}\right)$$

$$= 21,000 \text{ CFS}$$

$STAGE_4$ (TRIAL) = 11.5 FT

$$V_4 = \frac{11.5' \times (11.5 \times 24) \times 1400}{43,560} = 102.0 \text{ AC-FT}$$

$$V_{AV} = \frac{V_3 + V_4}{2} = \frac{128.4 + 102.0}{2} = 115.2 \text{ AC-FT}$$

$$Q_{P4} = Q_{P3}\left(1 - \frac{V_{AV}}{S}\right) = 28,712\left(1 - \frac{115.2}{478}\right)$$

$$= 28,712(.759) = \underline{21,792 \text{ CFS}}$$

$STAGE_4 = 11.7$ FT

$$\boxed{\therefore \underline{\text{AT ROADWAY CROSSING}} \qquad Q_{P4} = 21,792 \text{ CFS} \\ (4400' \text{ DOWN STREAM}) \qquad STAGE_4 = 11.7 \text{ FT}}$$

✱ ASSUME ROADWAY WASHES OUT.

TRY $L_{REACH_4} = 2000'$

$$V_4 = \frac{2000' \times 11.7 \times (11.7 \times 24)}{43,560} = 150.8 < \frac{S}{2} \text{ (OK)}$$

$$Q_{P5} \text{ (TRIAL)} = Q_{P4}\left(1 - \frac{V_4}{S}\right) = 14,917 \text{ CFS}$$

D-18

$STAGE_5$ (TRIAL) = 10.2 FT

$$V_5 = \frac{10.2 \times (10.2 \times 24) \times 2000}{43,560} = 114.6 \; AC\text{-}FT$$

$$V_{AV} = \frac{V_4 + V_5}{2} = \frac{150.8 + 114.6}{2} = 132.7 \; AC\text{-}FT$$

$$Q_{P5} = Q_{P4}\left(1 - \frac{V_{AV}}{5}\right) = 21,792\left(1 - \frac{132.7}{478}\right)$$

$$= 15,742 \; CFS$$

$STAGE_5 = 10.3'$

$$\boxed{\therefore \quad \underline{AT \; 6400' \; DOWNSTREAM} - \; Q_{P5} = 15,742 \; CFS \\ STAGE_5 = 10.3'}$$

TRY $LREACH_5 = 3000$ FT

$$V_5 = \frac{3000 \times 10.3 \times 10.3 \times 24}{43,560} = 175.3 \; < \frac{5}{2} \quad OK$$

$$Q_{P6} \text{ (TRIAL)} = Q_{P5}\left(1 - \frac{V_5}{5}\right) = 15,742\left(1 - \frac{175}{478}\right)$$

$$= 9,980' \; CFS$$

$STAGE_6$ (TRIAL) = 8.6 FT.

$$V_6 = \frac{8.6 \, (8.6 \times 24) \times 3000}{43,560} = 122.2 \; AC\text{-}FT$$

$$V_{AV} = \frac{V_5 + V_6}{2} = \frac{175.3 + 122.2}{2} = 148.8$$

$$Q_{P_6} = Q_{P_5}\left(1 - \frac{V_{AV}}{2}\right) = 15{,}742\left(1 - \frac{147.7}{478}\right)$$

$$= 10{,}840 \; CFS$$

$$STAGE_6 = 8.9 \; FT$$

AT 9,400 FEET DOWNSTREAM $Q_{P_6} = 10{,}840 \; CFS$

$STAGE_6 = 8.9 \; FT$

D-20

FIG. 4, Sh. D-21

-REACH #3 & 4
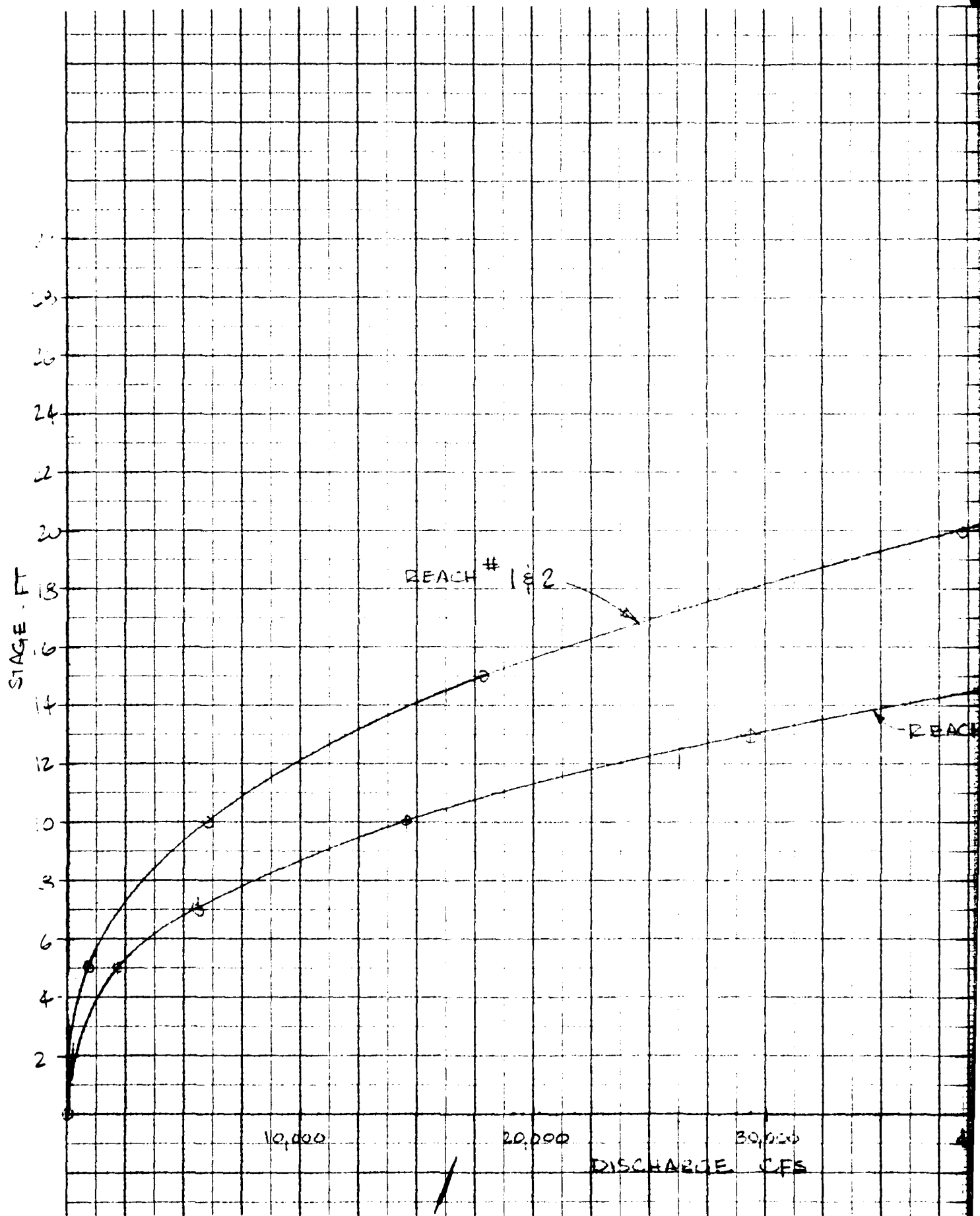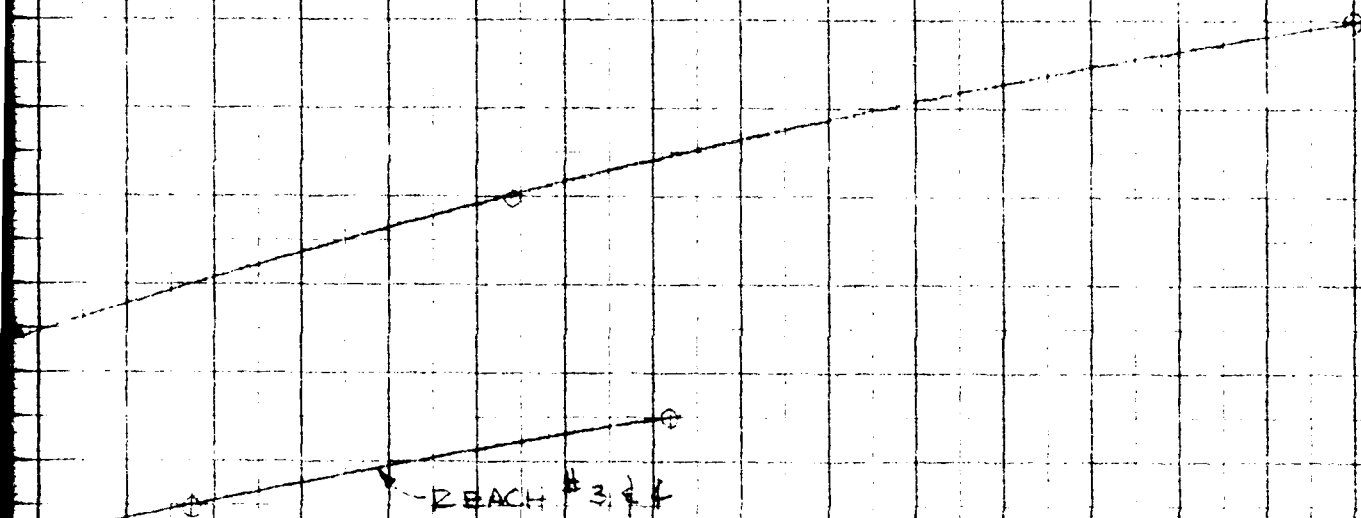
HOWARD RESERVOIR
STAGE-DISCHARGE RATING
CURVE

DOWNSTREAM

30,000   40,000   50,000   60,000

DISCHARGE CFS

D-21

AREA OF POTENTIAL FLOODING

HOWARD RES. DAM

DRAINAGE AREA

LOUIS BERGER & ASSOC., INC
WELLESLEY, MASS
ARCHITECT   ENGINEER

US ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

HOWARD RESERVOIR DAM

DRAINAGE AREA AND AREA
OF POTENTIAL FLOODING

STATE - CT.

| SCALE | 1 24000 |
| DATE | |

FIG 5, Sht D-22

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	CONGR DIST.
CT	15	NED	CT	003	01	

NAME

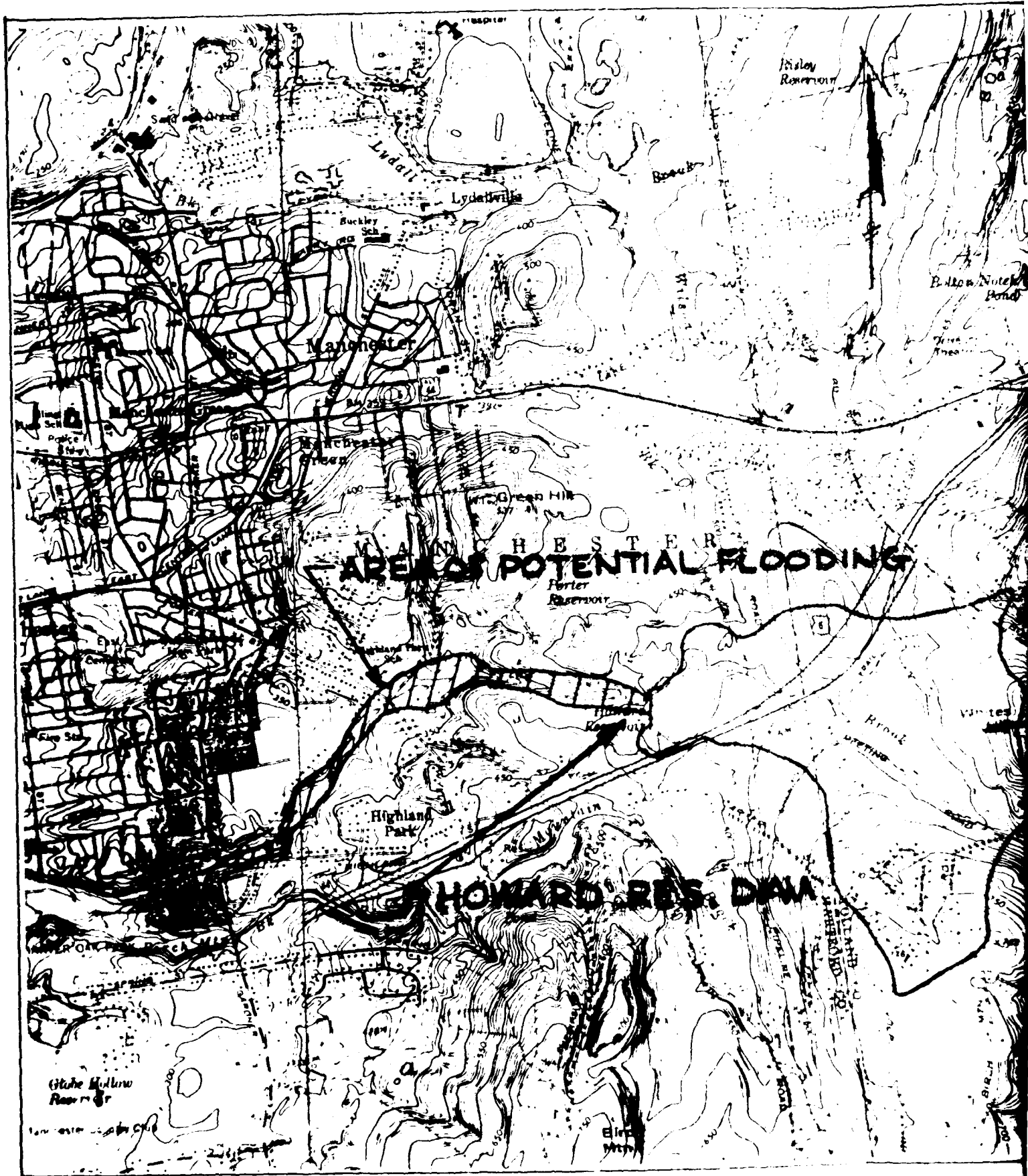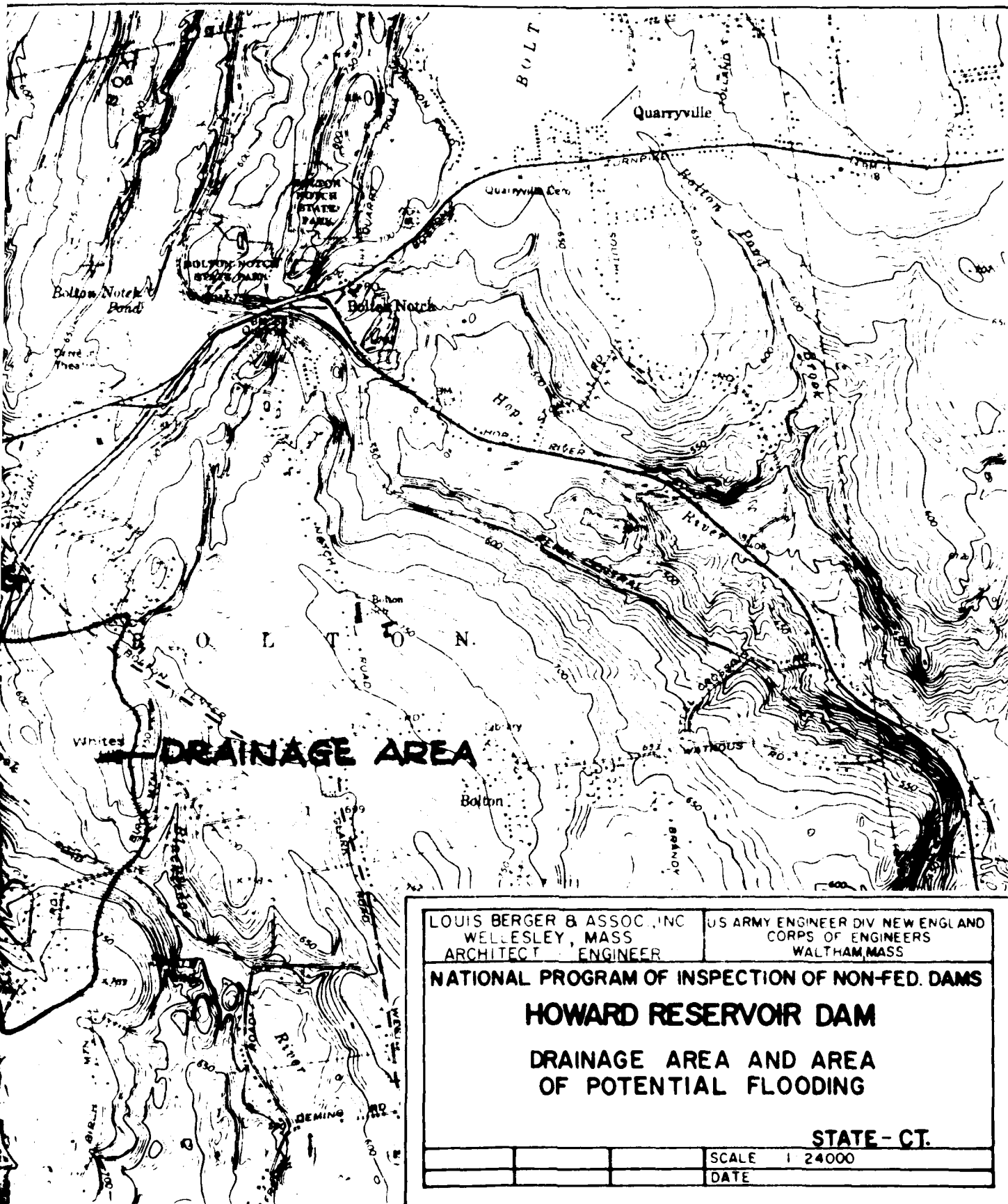HOWARD RESERVOIR DAM

LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY / MO / YR
4146.3	7228.7	30MAY79

POPULAR NAME

NAME OF IMPOUNDMENT

HOWARD RESERVOIR

RIVER OR STREAM

PORTER BROOK

NEAREST DOWNSTREAM CITY – TOWN – VILLAGE

MANCHESTER

DIST FROM DAM (MI.)	POPULATION
2	49200

REGION	BASIN
01	06

TYPE OF DAM	YEAR COMPLETED	PURPOSES
RE, PG	1902	S

IMPOUNDING CAPACITIES (ACRE-FT.)

STRUC. HEIGHT (FT)	HYDRAU HEIGHT (FT)	MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)
50	50	478	529

DIST	OWN	FED R	PRV/FED
NED	N	N	N

REMARKS

SPILLWAY CREST LENGTH	TYPE	WIDTH	MAXIMUM DISCHARGE (FT)	VOLUME OF DAM (CY)
710	U	10	967	151204

U/S HAS		
1		

POWER CAPACITY

INSTALLED (MW)	PROPOSED (MW)	NO.

NAVIGATION LOCKS

LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH

OWNER

CITY OF MANCHESTER

ENGINEERING BY

GUFFIN + FITZGERALD

CONSTRUCTION BY

CHENEY BROS

DESIGN

NONE

CONSTRUCTION

NONE

REGULATORY AGENCY

OPERATION

NONE

MAINTENANCE

NONE

INSPECTION BY

LOUIS BERGER + ASSOCIATES, INC

INSPECTION DATE DAY / MO / YR
09APR79

AUTHORITY FOR INSPECTION

PUBLIC LAW 92-367

REMARKS

PHV/FED	8C8	A	VER/DATE
N			30MAY79